ARMY ORDNANCE

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Founded 1920

Pledged to Industrial Preparedness as Our Strongest Guaranty of Peace

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THE ARMY ORDNANCE ASSOCIATION

The Aims, Purposes, and National Officers of the Society

THE Army Ordnance Association is a national organization of American citizens pledged to industrial preparedness for war as our nation's strongest guaranty of peace.

The Association endeavors to keep alive an interest in and knowledge of the design, production and maintenance of munitions. Under normal conditions there is no private peace-time industry in the United States for the production of ordnance. Should war unhappily come again, industrial America will be called upon to produce munitions in great quantity and of intricate and unusual design. In an emergency, time will not permit careful study or long preparation for the production of munitions. The problem is one of vital concern.

The Army Ordnance Association believes that the solution of this problem, based on experience, lies in an active organization at all times coöperating with the Government. The principal objective of the Association is an active membership of American citizens, on whom the duty of design and production of munitions will fall in war, who will have an accurate and authentic knowledge of the complex requirements of ordnance. "Peace insurance" in this form is the foremost aim of the Army Ordnance Association.

The Association is devoted solely to the national defense; it has no commercial interests, no political alliances, and no religious affiliations. It is not operated for profit: its income is expended in furthering its aims. Its officers and directors serve without remuneration. Membership, to which American male citizens are eligible, is four dollars a year. (Application on request.)

ARMY ORDNANCE, the journal of the Association, is published solely for the purpose of disseminating information on the progress of our munitions developments so that American industry may at all times know its responsibilities to the common defense.

The objectives of the Association as set forth in its Constitution are:

To assist in effecting industrial preparedness for war as being one of the nation's strongest guaranties of peace;

To keep available the highly specialized knowledge necessary for arming the manhood of the nation by stimulating interest in the design and production of ordnance material;

To promote mutual understanding and to effect coöperation with American scientists, inventors, engineers and manufacturers in civil life and the Regular and Reserve officers of the Ordnance Department;

To provide, when required, the services of competent committees to investigate and report upon special ordnance subjects;

To assist in developing and maintaining an efficient personnel, both commissioned and enlisted, for the units required for Ordnance Field Service in the event of an emergency;

To commemorate the services rendered by the industry of the nation and by the officers and civilian employees of the Ordnance Department in the wars in which the United States has been engaged.

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U. S. Army Air Corps

Winged Cannon

ARMY ORDNANCE

Volume XXII NOVEMBER-DECEMBER, 1941 No. 129

World Leader in Gun Making

Watertown Arsenal Continues a Record of 125 Years

Brig. Gen. R. W. Case *

THROUGHOUT the history of the development of the cannon, mobility—as well as fire power—has been a paramount consideration, just as it is today. The earliest cannon were single tubes of cast iron or bronze. As gunpowder improved, more and more metal was put into these guns until the mobility factor was practically destroyed. This forced a change to cast and then to forged steels which relieved the situation only temporarily. Competition among nations in hurling larger and larger projectiles to greater and greater distances employing ever-increasing powder charges dictated another change—the expediency of reënforcing the steel tubes by wrapping them with wire or by shrinking on forged jackets and hoops, or by both.

The history of gun making is intimately woven with the history of the Watertown Arsenal, Watertown, Mass., which is 125 years old this year. As one unit in the system of manufacturing, procuring, and research facilities of the Ordnance Department of the United States Army, the Watertown Arsenal has a continuous record of noteworthy achievements. It was through the research of this unit that the change-over from cast iron to forged steel was effected. Due to the efforts of the Ordnance Department in general, and of this arsenal in particular, the United States today leads the world in the science of gun making. Furthermore, it leads the world in mass-production methods of gun manufacture.

This has come about through three developments pioneered at the arsenal which are not only revolutionary but are evolutionary as well. Together or separately they constitute the greatest advancement in gun making since the inventions of rifling and the breechblock and put America far in advance of any other country in this science. These three steps are: (1) the casting of cannon by the centrifugal process—superseding forging; (2) cold working by the autofrettage method, and (3) the creation of stronger and tougher gun steels.

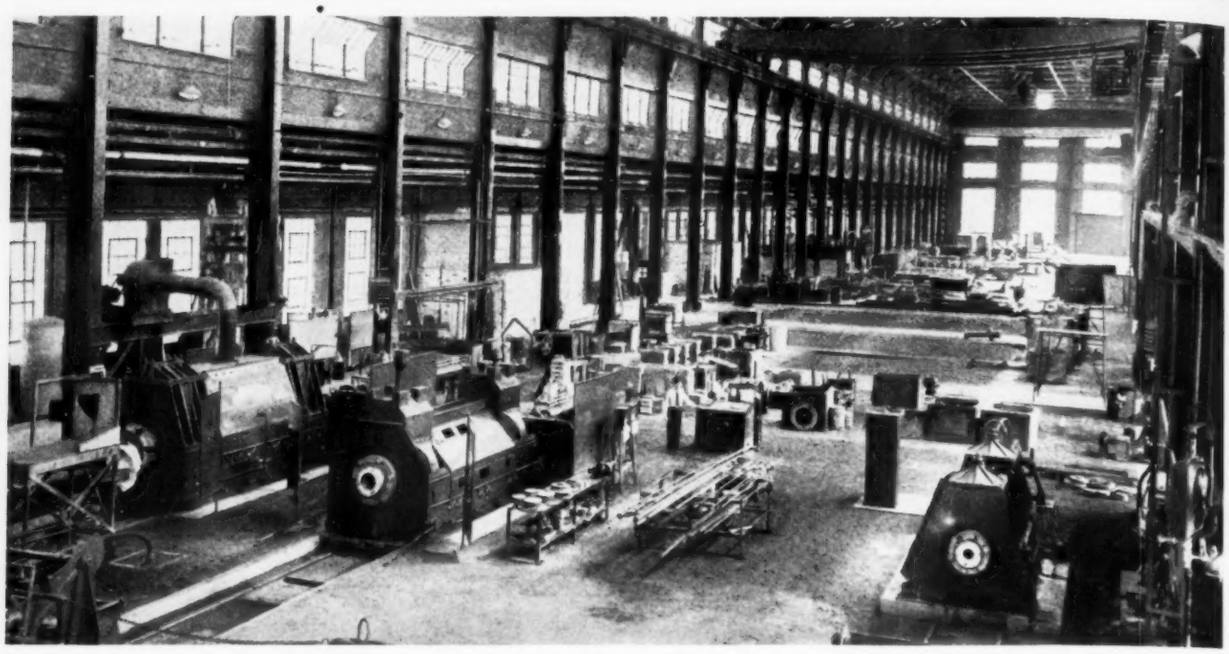
*Commanding Watertown Arsenal, Watertown, Mass. Brigadier General, U. S. Army.

THE road ahead is hard, but it was no easy road in 1816, when this arsenal was built. When the first Provincial Congress met here in Watertown in 1775 and voted to raise an army of 30,000 men to march against one of the greatest armies in Europe, nobody expected it would travel an easy road. It was not much of an army to look at. It was nondescript in uniform and short in weapons—but it was unbeatable in enthusiasm. The wailers of 1775 told the soldiers that they had better give up and go home before they got into trouble, but the Army didn't pay much attention to that. . . . Today the arsenals of Springfield and Watertown and the Navy Yard at Charlestown are monuments to their sagacity and wisdom. We are fortunate in that they are good, strong, enduring monuments. We are fortunate in that the men who founded them knew human nature and the weaknesses of human nature. We are celebrating here today because they did not forget to insure the security of the young nation by building arsenals to protect it.—ROBERT P. PATTERSON, THE UNDER SECRETARY OF WAR.

While the Watertown Arsenal was really established in 1800 by President John Adams at Charlestown, Mass., it was moved to its present site at Watertown in 1816. That is the date from which the one hundred and twenty-fifth anniversary, celebrated this year, stems. This arsenal, therefore, has served the United States in every war since and including that of 1812. This plant primarily manufactures seacost gun carriages of all types, railway and antiaircraft gun mounts and, due to its successful development of centrifugal casting, cold working, etc., it also has become a gun-making plant.

Brig. Gen. T. J. Rodman, who commanded the arsenal from 1859 to 1861, was responsible for the developments covering the progressive burning of gun powder, the design of seacoast gun carriages and the development of the water-cooled chilling method for the bore of cast-iron cannon, thereby obtaining much the same effect as that sought by cold working today. Brig. Gen. T. C. Dickson, who commanded the arsenal from 1918 to 1933, is the officer more responsible than any one else for the development of the laboratory at Watertown, the development of centrifugal casting, cold working, and the welding of gun carriages.

Centrifugal casting has greatly speeded the making of guns, for a single casting machine will turn out several gun tubes in the time it takes to forge one, and subsequent machining is reduced materially. The new process of cold working so improves the physical characteristics that the time-honored built-up sections of separately forged jackets and hoops shrunk onto the tubes and each other have become obsolete; instead, there is a single tube that is superior in every way. This is known as the monobloc type of gun, the standard type of antiaircraft gun today. The elimination of forging these sections, shrinking them on, and the reduced amount of machining required constitute savings in time, labor, and material ranging from twenty-five to forty per cent. The reduction in weight is considerable and is used in many guns to regain mobility.



PART OF THE CENTRIFUGAL-CASTING PLANT AT WATERTOWN ARSENAL

IN the research laboratory at Wartertown, many steels have been developed. Here were created the nickel steels so widely used in the automotive industry today; the molybdenum high-speed tool steel, a substitute for the tungsten high-speed tool steel and more lately the chromium-molybdenum-vanadium gun steels that are now used in making the guns. The guns cast here by the new process include the 37-mm., the 40-mm., the 90-mm., the 105-mm., and the new model 3-inch—in fact, everything from the 1.1-inch to the 4.5-inch, and preparations are being made to cast even larger sizes.

The idea of centrifugally casting thin-walled pipe or pouring molten metal into swiftly revolving tubular molds is very old. However, it took the personnel of the Watertown Arsenal many years of constant work to solve the myriad physical and metallurgical problems involved in adapting this method to the manufacture of guns. In the present building devoted to this work, platforms are located at both ends to hold the electric melting furnaces, which are of the coreless induction, high-frequency type. There are several production lines with casting machines, a large cinder bed in the center for cooling the guns, and a row of furnaces on one side in which the guns are normalized. The melting furnaces range in size so as to hold exactly the amount of steel needed for each size and type of gun when pouring.

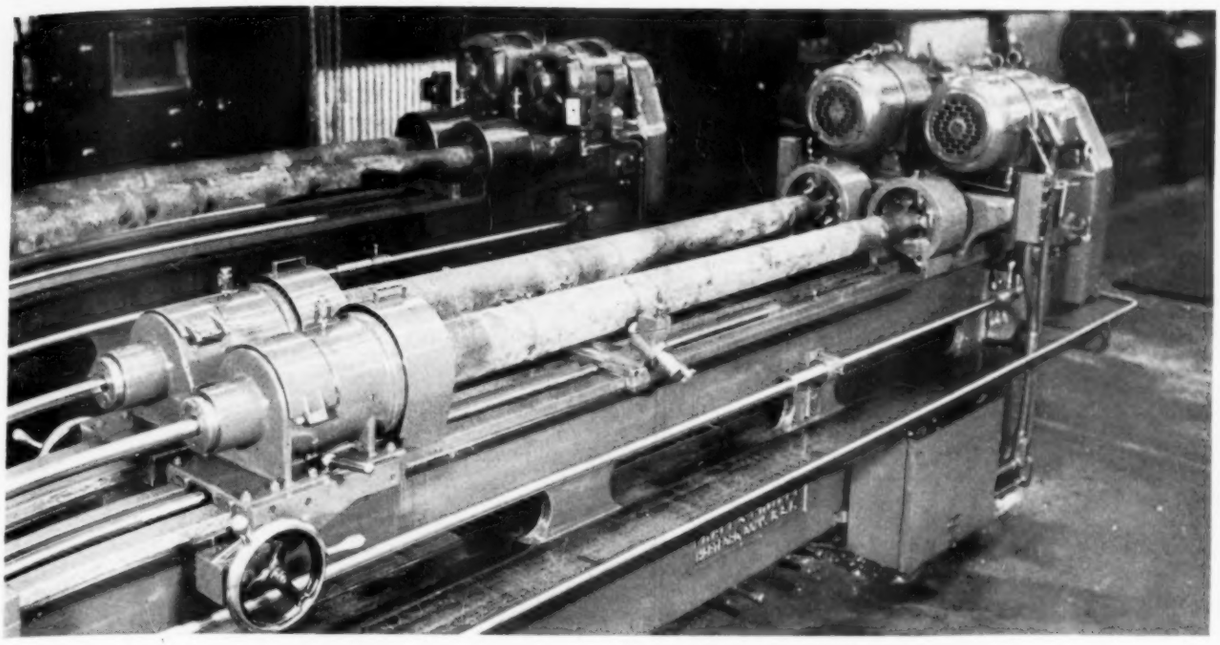
The molding machine is a long horizontal cast tube, weighing from five to ten tons, which is rotated at a high rate of speed by a motor. Into this is fitted any one of several tubes or molds, bored out to the exact exterior dimensions of the type of gun to be cast, due allowance being made for shrinkage, cold working, etc. These molds weigh from three to four tons each. In front of the machine is a track with a tipping car on it. When the metal is melted, the entire furnace is picked up by one of several overhead cranes and is placed in this tipping car. A pouring box with a nipple is then placed between the furnace and the closed end of the casting machine with the nipple protruding through an opening in the cover of the casting tube. The molten metal is then poured into the mold through the pouring box by tipping the furnace. The poured charges range from 450 to 5,000 pounds each, according to the size of the gun being cast. Both molds and pouring boxes are preheated prior to pouring.

As soon as the casting has cooled sufficiently, the end cover of the casting machine and mold is unbolted and the hot gun is pushed out by means of a hydraulic ram. A crane removes it to the cinder floor where it is buried in cinders until cold. One of several oil-fired, car-bottom type furnaces then receives it and it is normalized. After remaining at normalizing temperature the proper length of time, it is withdrawn and air-cooled (quenched).

In an adjoining building are a large number of vertical cylindrical oil-fired furnaces for heat treating. The gun is now lowered into one of these and heated to temperature and is then given a differential quench by dipping it several times, large end first, into water. This is necessary as the gun is much larger at the breech than at the muzzle and this treatment insures uniformity in physical characteristics throughout. Finally, the gun is drawn ready for machining.

In casting, the weight of the metal plus the centrifugal force of rotation throws all the slag and inclusions to the center. Only a small center hole is left so that all the dirty steel is eliminated when the gun is bored.

GREAT strides also have been made at Watertown in boring and machining the guns cast there. In fact, a single machine has been designed to bore the center and machine the exterior surface simultaneously. Of course a lot of old equipment is still in use, but even this has been modernized. For instance, turning lathes for finishing the outside of guns have been equipped with six tool posts so that six cuts are taken at once, thereby reducing the machining time to almost one sixth. There are also boring lathes with twin headstocks and twin tailstocks so that two guns can be bored simultaneously. A hydraulic straightening press is employed to straighten any tubes that are out of line. The cast-iron molds are all bored and machined in this department. An-



Deep-Hole Drilling Machine at Watertown for Boring Two Gun Barrels Simultaneously

other great saving in this type of gun is the cutting of the rifling directly into the bore instead of inserting a separate liner as formerly.

Steel mills long have taken advantage of the fact that extensive cold and hot working make steels stronger and tougher. Pressing between two surfaces such as rolls and forging dies was easy, but with a thick-walled steel tube the amount of this working was strictly limited. Watertown solved the problem by placing the gun tube within a huge, cast-steel container and pressing it from the inside by hydraulic pressure. This innovation was started just prior to the World War. By applying a high pressure, the diameter of the bore of the gun is materially increased and the elastic limit of the steel is almost doubled. At the same time, another fundamental change takes place in the gun wall, thus solving another problem. This cold working puts the layers of metal near the bore under compression by the contracting force of the outer layers, just as the shrunk-on jackets and hoops formerly did. This cold working allows an increase of very nearly one hundred per cent in powder charge and projectile weight without increasing the wall thickness or weight of the cannon. This lends a tremendous increase to the traveling speed of mobile artillery today while at the same time preserving maximum fire power.

The bombing airplane and its antidote, the antiaircraft gun, made necessary an entirely new type of gun carriage to permit high-angle elevation. New and practical designs were successfully developed at Watertown and put into mass production. Full advantage was taken of the welding process in designing carriages and mounts to simplify their manufacture and decrease their weight. This was accomplished by substituting built-up welded structures in place of heavy cast-steel parts.

It might almost be said that the greatest epoch in gun-making history was that period immediately following the World War and that all this progress was made by the Ordnance Department of the U. S. Army at the Watertown Arsenal. However, this progress would have been impossible without the aid of the arsenal's research department. Ferrous research for the entire Ordnance Department is centered at this laboratory which has long pioneered in the development of ferrous metals and metallurgical methods. Its influence on commercial industry in general and war matériel in particular has been profound.

Here was built the first machine for testing the strength of metals. Findings made with this and similar machines led to the change-over from cast iron to steel in the manufacture of guns. Here, all incoming raw material and material in process are checked chemically, structurally, and physically. One machine here has a testing capacity of one million pounds, and the world's largest impact testing machine is also part of the equipment. Here also was developed the armor-piercing projectile.

Examination of steel parts for defects is made by photographing them with X-rays for the thinner sections, but radium is employed in photographing the large and thick pieces. While the chemical laboratory is the first and last resort for steel analysis, a fast test of gun samples is made spectrographically. A continuous electric spark between two parts of the same sample is observed through a spectroscope and the spectrum compared with that of a section of known analysis. A densitometer measures the actual density of the lines of the spectrum and this gives the actual percentages of the different alloys.

A most important research problem now engrossing the laboratory is the development of better armor plate and armor-plate steels of low alloy content; that is, steels benefited by the strategic metals. The staff is now coöperating with fifty industrial firms in developing cast and rolled armor plate for aircraft, helmet, and body armor. Also a technique for the welding of armor is being developed. This includes a conciliation of the metallurgical and ballistic characteristics to determine those properties essential to armor plate. As a result, several firms have already qualified and are making both cast and rolled armor plate.

Organization for Production, II

The Ordnance System of Decentralized Operation

THE continuing growth of the Ordnance Department's facilities for armament production is demonstrated in the following list and on the map facing page 364. Since March 1, 1941, contracts have been let for the construction and operation of twenty-two new Ordnance establishments (shown in yellow on the map). It will be noted that the majority of the new plants are being situated in the central and mid-western section of the country. Ordnance arsenals, depots, plants, works, and proving grounds in existence or contracted for as of March 1, 1941, are shown in blue on the map. The contractors listed below are those operating the various plants.

This vast industrial organization stems from the Office of the Chief of Ordnance in Washington. However, following the Ordnance principle of centralized control with decentralized operation, these numerous facilities are administered through the thirteen Ordnance districts, embracing the entire United States. These districts, under civilian leadership, have been conducting plant surveys and allocations for the past twenty years and are responsible for the swiftness and thoroughness with which the present gigantic armament effort got under way. Ordnance district and regional headquarters are shown in red on the map and the various Ordnance districts are outlined in red.

For easy reference, this list is compiled in alphabetical order, and the numerals on the map correspond with those in this list. This list and map supplement and bring up to date a similar list and map published in the March-April 1941 issue of ARMY ORDNANCE *(Vol. XXI, No. 125, p. 466).*

1. ABERDEEN PROVING GROUND—Aberdeen, Md. Proof of equipment and ammunition. *Commanding Officer:* Brig. Gen. J. B. Rose.

2. ALABAMA ORDNANCE WORKS—Sylacauga, Ala. Smokeless powder. *Contractor:* E. I. du Pont de Nemours & Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. J. D. McIntyre.

3. ALABAMA ORDNANCE WORKS—Sylacauga, Ala. TNT, DNT and tetryl. *Contractor:* E. I. du Pont de Nemours & Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. J. D. McIntyre.

4. ANNISTON ORDNANCE DEPOT—Anniston, Ala. Ammunition and general supplies storage. *Commanding Officer:* Capt. John W. Quickmire.

5. ARKANSAS ORDNANCE PLANT—Jacksonville, Ark. Fuze and detonator loading plant. *Contractor:* Ford, Bacon, & Davis, New York, N. Y. *Commanding Officer:* Lieut. Col. W. H. Joiner.

6. ARMOR PLATE PLANT—Philadelphia, Pa. *Contractor:* Henry Disston & Sons, Inc., Philadelphia, Pa. *Jurisdiction:* Philadelphia Ordnance District.

7. AUGUSTA ORDNANCE DEPOT—Augusta, Ga. General supplies and storage. *Commanding Officer:* Lieut. Col. A. H. Skinner.

8. BAYTOWN ORDNANCE WORKS—Baytown, Tex. Toluol plant. *Contractor:* Humble Oil & Refining Company, Houston, Tex. *Commanding Officer:* Col. J. G. Booton.

9. BENICIA ORDNANCE DEPOT—Benicia, Calif. General supplies and ammunition storage. *Commanding Officer:* Col. P. J. R. Kiehl.

10. BIRMINGHAM ORDNANCE DISTRICT—700 Frank Nelson Building, Birmingham, Ala. *Chief:* Col. Theodore Swann; *Executive Officer:* Lieut. Col. W. F. Vander Hyden.

11. BOSTON ORDNANCE DISTRICT—Room 1501, 140 Federal Street, Boston, Mass. *Chief:* Col. Charles H. Tenney; *Executive Officer:* Lieut. Col. James S. Crawford.

12. CHARLESTON ORDNANCE DEPOT—North Charleston, S. C. Ammunition storage and loading plant. *Commanding Officer:* Col. Roger Taylor.

13. CHICAGO ORDNANCE DISTRICT—38 South Dearborn Street, Chicago, Ill. *Chief:* Frederick A. Preston; *Executive Officer:* Col. Donald Armstrong.

14. CINCINNATI ORDNANCE DISTRICT—Room 831, The Enquirer Bldg., Cincinnati, Ohio. *Chief:* Edward A. Muller; *Executive Officer:* Lieut. Col. Fred A. McMahon.

15. CLEVELAND ORDNANCE DISTRICT—1450 Terminal Tower Building, Cleveland, Ohio. *Chief:* Col. Winthrop Withington; *Executive Officer:* Lieut. Col. H. M. Reedall.

16. COOSA RIVER ORDNANCE PLANT—Talladega, Ala. Bag-loading plant. *Contractor:* Brecon Loading Company, Talladega, Ala. *Commanding Officer:* Lieut. Col. J. D. McIntyre.

17. CURTIS BAY ORDNANCE DEPOT—South Baltimore, Md. Ammunition storage and loading plant. *Commanding Officer:* Lieut. Col. H. A. Willis.

18. DAYTON MACHINE GUN PLANT—Dayton, Ohio. *Contractor:* General Motors Corporation, Detroit, Mich. *Jurisdiction:* Detroit Ordnance District.

19. DELAWARE ORDNANCE DEPOT—Pedricktown, N. J. Ammunition storage and loading plant. *Commanding Officer:* Lieut. Col. J. E. Brown.

20. DENVER ORDNANCE PLANT—Denver, Colo. Small-arms ammunition plant. *Contractor:* Remington Arms Company, Bridgeport, Conn. *Commanding Officer:* Lieut. Col. Duncan G. McGregor.

21. DES MOINES ORDNANCE PLANT—Des Moines, Iowa. Small-arms ammunition plant. *Contractor:* U. S. Rubber Company, New York, N. Y. *Commanding Officer:* Capt. W. L. Bell, Jr.

22. DETROIT ORDNANCE DISTRICT—1832 National Bank Building, Detroit, Mich. *Chief:* Alex Dow; *Executive Officer:* Lieut. Col. Richard Z. Crane.

23. DETROIT TANK ARSENAL—Detroit, Mich. Medium tanks. *Contractor:* Chrysler Corporation, Detroit, Mich. *Commanding Officer:* Lieut. Col. H. W. Rehm.

24. DIXIE ORDNANCE WORKS—Sterlington, La. Ammonia plant. *Contractor:* Commercial Solvents, New York, N. Y. *Commanding Officer:* Maj. R. H. Coombs.

25. ELWOOD ORDNANCE PLANT—Joliet, Ill. Shell-loading plant. *Contractor:* Sanderson & Porter, New York, N. Y. *Commanding Officer:* Lieut. Col. T. C. Gerber.

26. ERIE PROVING GROUND—Lacarne, Ohio. General supplies storage and ammunition storage. *Commanding Officer:* Lieut. Col. Thomas K. Vincent.

27. FLINT MACHINE GUN PLANT—Flint, Mich. *Contractor:* General Motors Corporation, Detroit, Mich. *Jurisdiction:* Detroit Ordnance District.

28. FRANKFORD ARSENAL—Philadelphia, Pa. Fire-control instruments, small-arms ammunition, and artillery ammunition. *Commanding Officer:* Brig. Gen. W. P. Boatwright.

29. GADSDEN ORDNANCE PLANT—Gadsden, Ala. Shell-forging and machining plant. *Contractor:* Lansdowne Steel & Iron Company, Morton, Pa. *Commanding Officer:* Capt. J. S. Walker.

30. HARTFORD MACHINE GUN PLANT—Hartford, Conn. *Contractor:* Colt's Patent Fire Arms Manufacturing Company, Hartford, Conn. *Jurisdiction:* Hartford Ordnance District.

31. HARTFORD ORDNANCE DISTRICT—95 State Street, Springfield, Mass. *Chief:* Col. Frederick H. Payne; *Executive Officer:* Lieut. Col. W. S. Broberg.

32. HOOSIER ORDNANCE PLANT—Charlestown, Ind. Bag-loading plant. *Contractor:* Goodyear Engineering Corporation, Akron, Ohio. *Commanding Officer:* Lieut. Col. R. E. Hardy.

33. ILLINOIS ORDNANCE PLANT—Marion, Ill. Shell-loading plant. *Contractor:* Sherwin-Williams Company, Cleveland, Ohio. *Commanding Officer:* Lieut. Col. L. M. Van Gieson.

34. INDIANA ORDNANCE WORKS—Charlestown, Ind. Smokeless-powder plant. *Contractor:* E. I. du Pont de Nemours & Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. R. E. Hardy.

35. IOWA ORDNANCE PLANT—Burlington, Iowa. Shell-loading plant. *Contractor:* Day & Zimmerman Company, Philadelphia, Pa. *Commanding Officer:* Lieut. Col. Otto M. Jank.

36. JAYHAWK ORDNANCE WORKS—Baxter Springs, Kans. Ammonia and ammonium-nitrate plant. *Contractor:* Military Chemical Works, Inc., Kansas City, Mo. *Commanding Officer:* Lieut. Col. S. R. Kimble.

37. JEFFERSON PROVING GROUND—Madison, Ind. Proof of equipment and ammunition. *Commanding Officer:* Lieut. Col. DeR. C. Cabell.

38. KANKAKEE ORDNANCE WORKS—Joliet, Ill. TNT and DNT plant. *Contractor:* E. I. du Pont de Nemours & Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. T. C. Gerber.

39. KANSAS ORDNANCE PLANT—Parsons, Kans. Shell-loading plant. *Contractor:* Johns Manville Company, New York, N. Y. *Commanding Officer:* Lieut. Col. Otto M. Jank.

40. KINGSBURY ORDNANCE PLANT—LaPorte, Ind. Shell-loading. *Contractor:* Todd & Brown, New York, N. Y. *Commanding Officer:* Maj. W. J. D'Espinosa.

41. LAKE CITY ORDNANCE PLANT—Lake City, Mo. Small-arms ammunition plant. *Contractor:* Remington Arms Company, Bridgeport, Conn. *Commanding Officer:* Lieut. Col. W. J. Crowe.

42. LONE STAR ORDNANCE PLANT—Texarkana, Tex. Shell-loading plant. *Contractor:* Lone Star Defense Corporation, Akron, Ohio. *Commanding Officer:* Maj. J. J. Breen.

43. LOS ANGELES ORDNANCE REGION—409 Chamber of Commerce Building, Los Angeles, Calif. *Executive Officer:* Lieut. Col. A. R. Baird.

44. LOUISIANA ORDNANCE PLANT—Minden, La. Shell-loading plant. *Contractor:* Silas Mason Company, Shreveport, La. *Commanding Officer:* Maj. J. J. Breen.

45. MAUMELLE ORDNANCE WORKS—Marche, Kans. Ammonium-picrate plant. *Contractor:* Cities Service Defense Corporation, Shreveport, La. *Commanding Officer:* Lieut. Col. W. H. Joiner.

46. MILAN ORDNANCE DEPOT—Milan, Tenn. Ammunition storage. *Commanding Officer:* Capt. J. Horridge.

47. MISSISSIPPI ORDNANCE PLANT—Flora, Miss. Bag-loading plant. *Contractor:* General Tire Engineering Company, Jackson, Miss. *Commanding Officer:* Maj. R. H. Coombs.

48. MISSOURI ORDNANCE WORKS—Louisiana, Mo. Ammonia plant. *Contractor:* Hercules Powder Company, Wilmington, Del. *Commanding Officer:* Maj. C. R. Dutton.

49. MORGANTOWN ORDNANCE WORKS—Morgantown, W. Va. Ammonia plant. *Contractor:* E. I. du Pont de Nemours & Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. John Huling, Jr.

50. MUSCLE SHOALS—Ala. Ammonia and ammonium-nitrate plant. *Agency:* Tennessee Valley Authority.

51. NANSEMOND ORDNANCE DEPOT—Portsmouth, Va. Ammunition storage and loading plant. *Commanding Officer:* Lieut. Col. C. C. Terry.

52. NEW RIVER ORDNANCE PLANT—Pulaski, Va. Bag-loading plant. *Contractor:* Hercules Powder Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. M. M. Serrem.

53. NEW YORK ORDNANCE DISTRICT—Room 1815, 80 Broadway, New York, N. Y. *Chief:* Brig. Gen. Samuel McRoberts; *Executive Officer:* Col. John K. Clement.

54. OFFICE OF THE CHIEF OF ORDNANCE—Social Security Building, Washington, D. C.

55. OGDEN ORDNANCE DEPOT—Ogden, Utah. Ammunition and general-supply storage. *Commanding Officer:* Lieut. Col. J. W. Proctor.

56. OHIO RIVER ORDNANCE WORKS—Henderson, Ky. Ammonia plant. *Contractor:* Atmospheric Nitrogen Corporation, Hopewell, Va. *Commanding Officer:* Lieut. Col. L. M. Van Gieson.

57. OKLAHOMA ORDNANCE WORKS—Choteau, Okla. Smokeless-powder plant. *Contractor:* E. I. du Pont de Nemours & Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. S. R. Kimble.

58. 155-MM. CANNON PLANT—Homestead, Pa. *Contractor:* Mesta Machine Company, Pittsburgh, Pa. *Jurisdiction:* Pittsburgh Ordnance District.

59. PHILADELPHIA ORDNANCE DISTRICT—Room 1300 Mitten Building, Philadelphia, Pa. *Chief:* Charles J. Ingersoll; *Executive Officer:* Lieut. Col. D. N. Hauseman.

60. PICATINNY ARSENAL—Dover, N. J. Smokeless powder, high explosives, and loaded ammunition. *Commanding Officer:* Brig. Gen. E. M. Shinkle.

61. PITTSBURGH ORDNANCE DISTRICT—1202 Chamber of Commerce Building, Pittsburgh, Pa. *Chief:* J. Daniel Berg; *Executive Officer:* Lieut. Col. James L. Guion.

62. PLUM BROOK ORDNANCE PLANT—Sandusky, Ohio. TNT and DNT plant. *Contractor:* Trojan Powder Company, Allentown, Pa. *Commanding Officer:* Capt. J. F. Rodenhauser.

63. RADFORD ORDNANCE WORKS—Radford, Va. Smokeless-powder plant. *Contractor:* Hercu'es Powder Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. M. M. Serrem.

The Growing Ordnance Establishment for Mili

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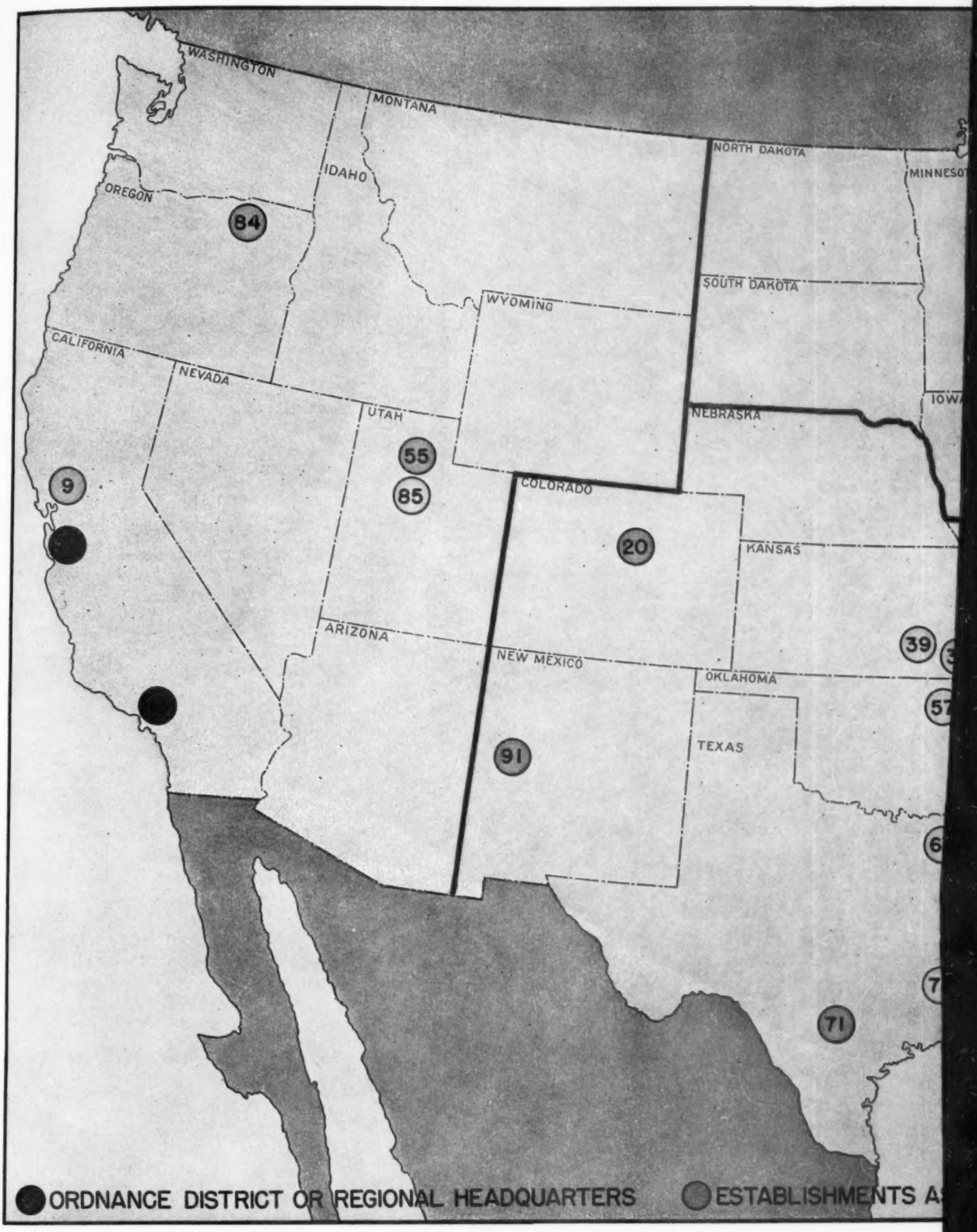

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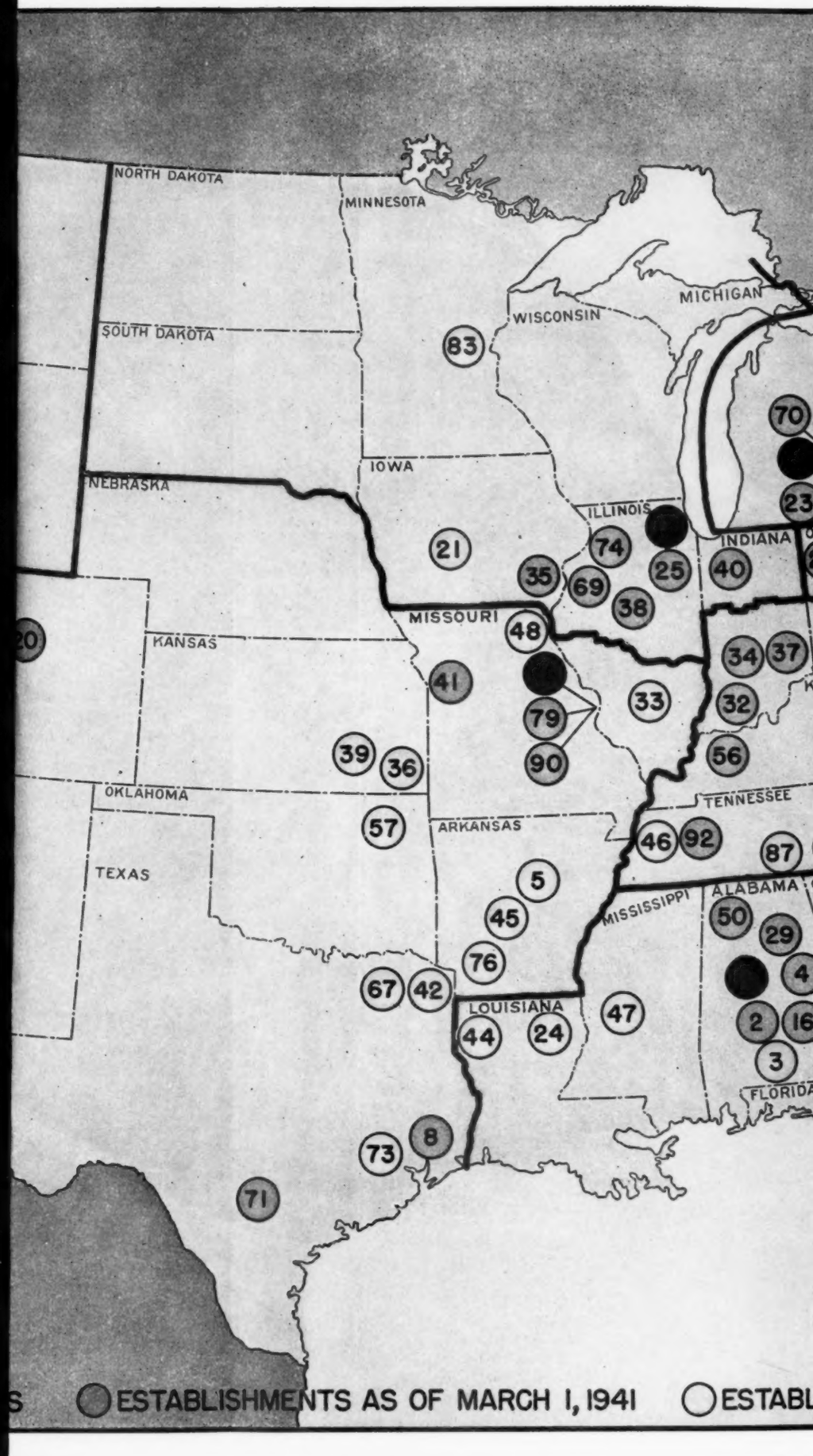

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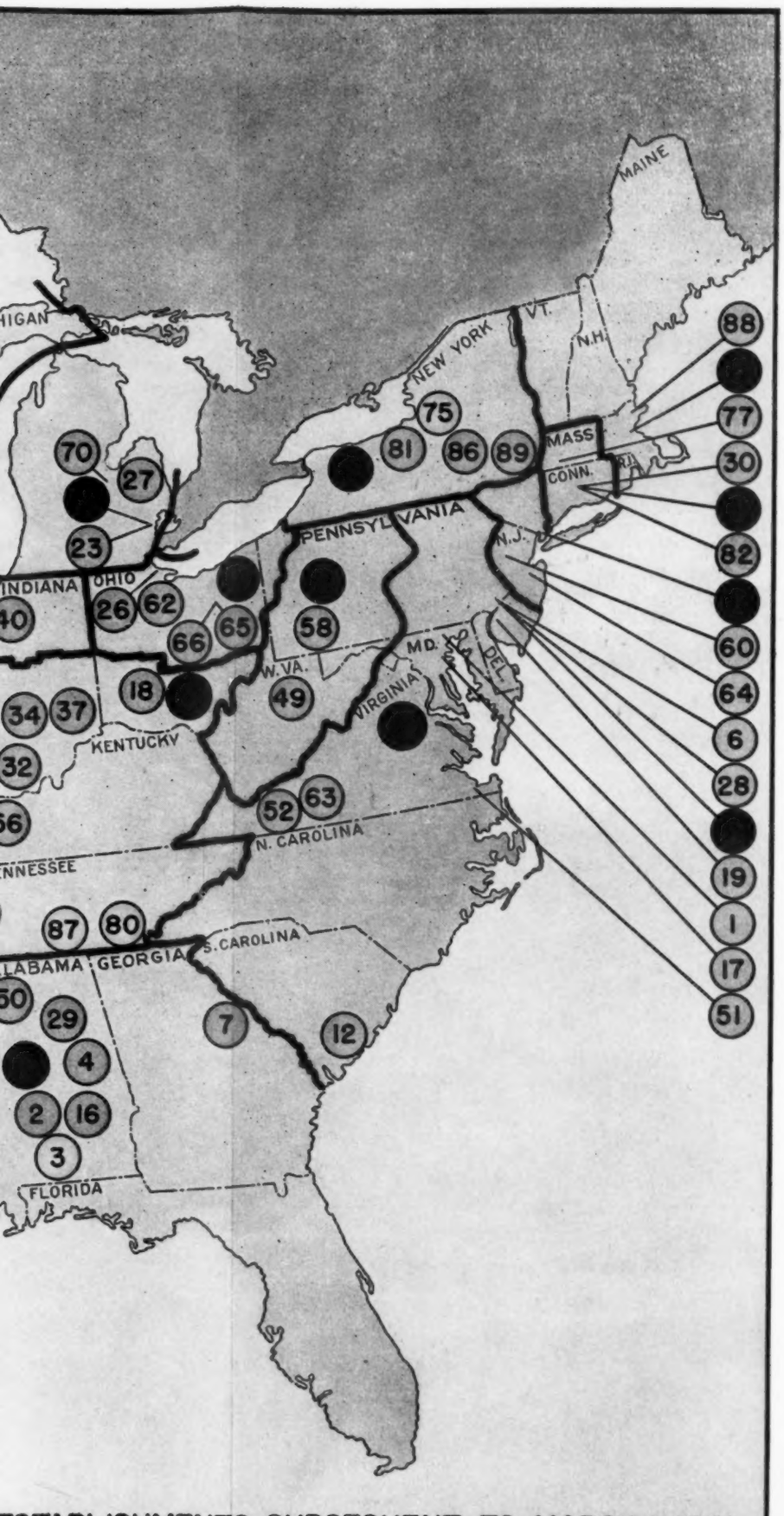


ESTABLISHMENTS SUBSEQUENT TO MARCH 1, 1941

64. RARITAN ORDNANCE DEPOT—Metuchen, N. J. General-supplies storage, ammunition storage, and loading plant. *Commanding Officer:* Lieut. Col. John A. Woodberry.

65. RAVENNA ORDNANCE DEPOT—Ravenna, Ohio. Ammunition storage and general-supplies storage. *Commanding Officer:* Lieut. Col. R. S. Chavin.

66. RAVENNA ORDNANCE PLANT—Ravenna, Ohio. Shell-loading plant. *Contractor:* Atlas Powder Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. R. S. Chavin.

67. RED RIVER ORDNANCE DEPOT—Texarkana, Tex. Ammunition storage.

68. ROCHESTER ORDNANCE DISTRICT—1238 Mercantile Building, Rochester, N. Y. *Chief:* Erwin R. Davenport; *Executive Officer:* Lieut. Col. Roy L. Bowlin.

69. ROCK ISLAND ARSENAL—Rock Island, Ill. Gun carriages and combat vehicles. *Commanding Officer:* Brig. Gen. N. F. Ramsey.

70. SAGINAW MACHINE GUN PLANT—Saginaw, Mich. *Contractor:* General Motors Corporation, Detroit, Mich. *Jurisdiction:* Detroit Ordnance District.

71. SAN ANTONIO ORDNANCE DEPOT—San Antonio, Tex. General supplies and storage. *Commanding Officer:* Col. J. G. Booton.

72. SAN FRANCISCO ORDNANCE DISTRICT—402 Hotel Empire, San Francisco, Calif. *Chief:* Samuel Kahn; *Executive Officer:* Col. K. B. Harmon.

73. SAN JACINTO ORDNANCE DEPOT—Houston, Tex. Ammunition storage and shipping terminal.

74. SAVANNA ORDNANCE DEPOT—Savanna, Ill. Ammunition storage and loading plant. *Commanding Officer:* Lieut. Col. L. P. Crim.

75. SENECA ORDNANCE DEPOT—Kendaia, N. Y. Ammunition storage. *Commanding Officer:* Capt. Jay L. Clark.

76. SOUTHWESTERN PROVING GROUND—Hope, Ark. Proof of equipment and ammunition. *Commanding Officer:* Lieut. Col. DeR. C. Cabell.

77. SPRINGFIELD ARMORY—Springfield, Mass. Machine guns and rifles. *Commanding Officer:* Brig. Gen. G. H. Stewart.

78. ST. LOUIS ORDNANCE DISTRICT—935 U. S. Custom and Court House, St. Louis, Mo. *Chief:* Col. Harry Scullin; *Executive Officer:* Maj. Randall J. Hogan.

79. ST. LOUIS ORDNANCE PLANT—St. Louis, Mo. Small-arms ammunition plant and bullet-core plant. *Contractors:* U. S. Cartridge Company, East Alton, Ill.; McQuay Norris Manufacturing Company, St. Louis, Mo. *Commanding Officer:* Maj. D. L. Van Syckle.

80. SULPHURIC ACID PLANT (EAST TENNESSEE ORDNANCE WORKS)—Copper Hill, Tenn. *Contractor:* Tennessee Copper Company, New York, N. Y.

81. SYRACUSE MACHINE GUN PLANT—Syracuse, N. Y. *Contractor:* General Motors Corporation, Detroit, Mich. *Jurisdiction:* Detroit Ordnance District.

82. 37-MM. CANNON PLANT—Hartford, Conn. *Contractor:* Colt's Patent Fire Arms Manufacturing Company, Hartford, Conn. *Jurisdiction:* Hartford Ordnance District.

83. TWIN CITIES ORDNANCE PLANT—Minneapolis, Minn. Small-arms ammunition plant. *Contractor:* Federal Cartridge Company, Minneapolis, Minn. *Commanding Officer:* Maj. John H. Hinrichs.

84. UMATILLA ORDNANCE DEPOT—Hermiston, Oreg. Ammunition storage. *Commanding Officer:* Capt. J. M. Piercy.

85. UTAH ORDNANCE PLANT—Salt Lake City, Utah. Small-arms ammunition plant. *Contractor:* Remington Arms Company, Bridgeport, Conn. *Commanding Officer:* Lieut. Col. Duncan G. McGregor.

86. UTICA MACHINE GUN PLANT—Utica, N. Y. *Contractor:* Savage Arms Corporation, Utica, N. Y. *Jurisdiction:* Rochester Ordnance District.

87. VOLUNTEER ORDNANCE WORKS—Chattanooga, Tenn. TNT and DNT plant. *Contractor:* Hercules Powder Company, Wilmington, Del. *Commanding Officer:* Capt. J. S. Walker.

88. WATERTOWN ARSENAL—Watertown, Mass. Gun carriages and forgings. *Commanding Officer:* Brig. Gen. R. W. Case.

89. WATERVLIET ARSENAL—Watervliet, N. Y. Cannon. *Commanding Officer:* Brig. Gen. A. G. Gillespie.

90. WELDON SPRING ORDNANCE WORKS—Weldon Spring, Mo. TNT and DNT plant. *Contractor:* Atlas Powder Company, Wilmington, Del. *Commanding Officer:* Maj. C. R. Dutton.

91. WINGATE ORDNANCE DEPOT—Fort Wingate, N. Mex. Ammunition storage. *Commanding Officer:* Capt. Evan M. Johnson, IV.

92. WOLF CREEK ORDNANCE PLANT—Milan, Tenn. Shell-loading plant. *Contractor:* Proctor & Gamble Defense Corporation, Cincinnati, Ohio. *Commanding Officer:* Capt. Joseph Horridge.

Arsenal Craftsmen

Training Civilian Personnel at Rock Island Arsenal

Brig. Gen. N. F. Ramsey*

TO meet the enormous demands of the Ordnance Department for inspection and operating personnel, it has been necessary to inaugurate comprehensive training plans at all the manufacturing arsenals. Each such arsenal has its individual problems: At Springfield Armory and at Frankford Arsenal, the problems are mainly those of mass production of a relatively few items; at Rock Island Arsenal, the problems are more varied, for this establishment is engaged in the manufacture of machine guns, tanks, high-speed modern carriages and recoil mechanisms for antitank guns, and for light, medium, and heavy field artillery. With such diversified activities it is imperative to have a large number of all-around mechanics, and at the moment they are scarcer than the proverbial hen's teeth.

At Rock Island, personnel training deals with two groups: First, the personnel trained at the arsenal for service at other ordnance plants or establishments, including administrative personnel, inspectors, armament machinists and automotive mechanics; in the second group are the men who are being trained for work at the arsenal to meet the constantly increasing demand for skilled labor.

Of those trained to serve at other ordnance plants, the administrative personnel has been appointed from eligibles certified from Civil Service lists of administrative technicians, most of whom have had some college education. Our training of these men consists mainly in familiarizing them with arsenal administrative procedure, fiscal operation, procurement procedure, property control, civilian-personnel procedure, planning, and mail-and-record activities. Their instruction consists of lectures, reading, and actual work in each of the administrative divisions of the arsenal. This is a two months' course, and to date ten men have completed their instruction and have been assigned to new ordnance plants. Another group of ninety men is now being organized to meet the demands of new plants in process of being constructed. Of course, this training will cease as the new plants are completed.

THE training of Ordnance inspectors, however, gives promise of being more prolonged. These men come to us from various Ordnance procurement districts. We are conducting two concurrent training courses for inspectors at the present time. The first includes basic instruction in inspection problems while the second combines more advanced and comprehensive training with greater opportunity for actual experience in final-inspection procedure. Six groups of inspectors with a total of two hundred and seventy men have been trained in the basic course and a seventh group of fifty men is now being enrolled.

During the first half of the six weeks' basic course, lectures with shop and laboratory instruction are provided to acquaint the trainees with precision instruments and their use, with materials encountered in ordnance manufacture, and with the testing, heat treatment, and fabrication of metals. The second 3-week period is devoted to general inspection procedure with the final inspection of one of the following classes of equipment: mobile artillery carriages, automotive equipment, small arms, recoil mechanisms, or small-arms equipment.

An examination is given to all men shortly after they report for the basic course. This is an exploratory operation to determine their respective abilities in mathematics, in shop practice, in blueprint reading and in the use of precision instruments. Results usually have disclosed deficiencies in one or more of these subjects.

Deficiencies in mathematics have been particularly noticeable among those enrolled in the basic course. Demands from these embryo inspectors for assistance in this subject were so urgent that arrangements were made with a local high school in the neighboring city of Davenport, Iowa, to provide the teaching facilities required. The instruction is given two nights a week for two hours each during four weeks of the course. Attendance is optional, but interest was so great that four instructors were necessary for the last group of fifty-four men. The trainees are divided into sections in accordance with their grades on the preliminary examination so as to enable men with superior mathematical training to proceed more rapidly.

The supplementary training in blueprint reading consists of a 2-hour instruction period each Saturday morning at which attendance is voluntary. It is well attended, however, as a special series of exercises in drawing and blueprint reading must be completed by each trainee.

The chief of the gage laboratory at the arsenal provides supplementary training on precision instruments each Saturday afternoon during the course to those who desire it. Recently there has been made available to these inspector trainees a small supply of precision instruments for practice in their use.

As to the advanced course for inspectors, only those men are eligible who give promise of developing into leaders in their field. They not only must have completed the basic course at some arsenal but must have had some experience in ordnance inspection work. Two groups with a total of fifteen inspectors have just finished this advanced course at Rock Island Arsenal, and a third group is to be started shortly. It is a ten weeks' course and is planned to afford the maximum amount of training in actual final inspection work. One week is devoted to study and use of gages in the gage laboratory. Two weeks are spent in the chemical and physical laboratory to learn the methods used there to inspect materials and to familiarize the men with such procedure. The last seven weeks are occupied in gaining experience in the final inspection of the particular equipment which each man is to inspect in his particular district. This experience is acquired very practically by actually making the final inspection of matériel produced at the arsenal.

Efforts are made to develop leadership in the advanced group by means of daily conferences. At the beginning of the course, the officer in charge leads a discussion each day

*Commanding General, Rock Island Arsenal, Rock Island, Ill. Brigadier General, U. S. Army.

on some topic related to the training program. After several days of this procedure, each trainee is assigned a subject. This leads to the development of daily discussions which are handled by the inspectors themselves. This training should aid the men in dealing with other inspectors who later may come under their supervision.

Visual aids are employed in these training courses to facilitate the understanding of material presented in lectures; a balopticon with slide attachment and a motion-picture projector for sound films are permanent equipment.

The training courses which have been described are as nearly complete as the amount of available time and personnel will permit. Revisions are made from time to time in the content of the courses as the need arises, for we are making an all-out effort to train these men to become efficient ordnance inspectors.

THEN there are the armament machinists. In order to maintain modern ordnance matériel in service, it is essential that each large camp, post, or training center have qualified and experienced machinists on its staff. In ordinary times, the demand for such men is not great, but in the present emergency, with the large increases in the Army in the field and its many far-flung activities, there has been a heavy demand for armament machinists.

Prior to the present emergency, men needed for this purpose by the various field agencies of the Army were obtained from some one of the manufacturing arsenals. These men were employees who had been in the Ordnance service for several years, with wide experience in the various shops of the arsenal. They were suitable for assignment without additional training. However, even in those days the number of such men that could be spared from various departments of the manufacturing arsenals was limited.

Three groups of armament machinists, a total of 89 men, recently have been trained at the arsenal. These men are all machinists or toolmakers by trade when they are selected for this specialized training in ordnance matériel. As a result of experience in training men for this duty, a separate school has been established and competent instructors assigned. The course of instruction includes two weeks' training in small arms, three weeks on fire-control instruments, five weeks on automotive equipment (tanks), and six weeks on artillery—a total of sixteen weeks.

This course of instruction does not include classroom lectures nor is any home work required. Our aim in this instruction is to acquaint the trainee fully with all the details of assembly of the various pieces of combat equipment, the type of work necessary for the accuracy involved, and an acquaintance with the use of the parts list, which is very necessary if a man is to order replacement parts for a damaged piece of equipment. Fundamentals of design are also gone over in detail to give the trainee a background of the requirements and limitations of various types of equipment.

We believe this practical type of training is easier to teach and more readily picked up by the trainee than training which would be conducted in a classroom, either by text reference or by lectures. Many of the men who are taking this training have been out of school several years, and it is difficult for them to readjust themselves to study from textbooks. It also was felt that the men receiving this practical training would have more confidence in themselves if they were given a chance to become familiar with the various assemblies with which they will be concerned later.

While there is no classroom instruction, there are extensive examinations given from time to time, usually as each phase of this practical instruction is concluded, the purpose being to help the trainee coördinate the knowledge he has gained.

A class of forty armament machinists is to be kept in training at all times.

THE only remaining group that we train for service at other stations is the automotive mechanics' group. With the large number of automotive combat vehicles, light and medium tanks, scout cars and personnel carriers soon to be in the hands of troops, there is a definite need for trained automotive mechanics to keep this material in repair and in service. These men have been selected with the same care as the armament machinists from arsenal employees or from Civil Service registers. At one time or another, most of the men had held the position of foreman in a garage. They were given three months' intensive instruction in our shops on the maintenance, assembly, and repair of the ordnance vehicles which they would find in service. They were placed under the direct supervision of an assistant foreman who divided them up into small groups and turned them over to lead men who supervised their detailed instruction.

The men receiving this training, as well as those taking the armament machinists' course, were encouraged to keep notes on the data given them and upon their own observation. I am happy to say that so far all the trainees, both armament machinists and automotive mechanics, have been so enthusiastic over their instruction that they have spent many off-hours in comparing notes or discussing problems of mutual interest concerning their training.

Technical manuals, training regulations, and additional Standard Nomenclature Lists are available for reference for these trainees. Whenever possible, War Department films are obtained. All the automotive mechanics trained so far have been transferred to stations in the field—several to foreign service. A class of ten automotive mechanics is to be kept in training at all times.

SO much for the training of personnel for duty at other establishments. Let us now turn to the training of men for work at Rock Island Arsenal. In order to meet the constantly increasing demand for skilled labor, three plants are employed at the arsenal for the training of classified employees in noneducational designations for higher positions. They are the apprenticeship plan, the "in-service" training plan, and the incidental-assignment plan.

At the present time, the arsenal has in training 65 apprentice machinists pursuing a well-organized, 4-year course. The apprentice training system was revived at the arsenal 4½ years ago, and the first class of 35 young men completed the 4-year course in January 1941. All of these have remained on duty at the arsenal as machinists.

The apprentice-machinist course is divided roughly into two 2-year periods. The first period is spent in the apprentice shop under the immediate supervision of the apprentice school foreman and his assistant. This shop, which is set aside for the purpose, has a well-rounded line of machine tools and the training is such that by the end of the 2-year period all apprentices are capable of handling the simpler machine operations and of doing some production work.

During the second period, the apprentices are assigned straight production work, either in the apprentice shop or in

the production departments, under a very definitely organized routine designed to give the apprentice experience on all the common types of machine tools. During this part of the course, some time is also spent in the pattern shop and foundry, in the forge and heat-treat department, and in the laboratory.

During the entire four years of apprenticeship, one afternoon a week is given over to classroom instruction in shop mathematics, drawing, etc., and, in addition, each apprentice agrees to complete a correspondence-school course paralleling his work.

The number of machinists apprentices in training is but a small fraction of the number of machinists and toolmakers required, but their value in the arsenal organization cannot be measured by their number. The apprentices were originally selected from a Civil Service register on which there was a great competition for places. As a result, young men of a high type were selected, most of whom had completed their high-school courses. Because of their basic qualifications and thorough training in well-equipped shops and on a great variety of work, graduates of the apprentice school are unusually well qualified for advancement to executive positions.

WHILE we have found that apprenticeship is by far the most effective method of training all-around, highly skilled mechanics, in the present emergency other and more rapid methods of training have had to be utilized to provide personnel qualified to perform more specialized operations. Expansion of various departments of the arsenal has been accompanied by increasing difficulty in obtaining qualified personnel. During this expansion, experienced men must be trained not only to operate machines but also to take over additional responsibilities as assistant foremen and supervisors. The needed experience, which cannot be obtained through original employment in the numbers required, must be provided through "upgrading" plans in the arsenal itself.

By "upgrading," I mean the promotion of workers from one designation to another requiring more skill, in order to make the best possible use of their abilities. At Rock Island Arsenal, jobs fall into a progressive sequence, each requiring a greater degree of skill. For example, we have classified laborers, shop boys, and junior messengers at the bottom of the ladder. Just above them we have helpers for the various mechanics, then come assemblers, machine operators, turret-lathe operators, mechanics, and supervisors. The employees who show aptitude and are desirous of advancing themselves have opportunities to advance from one designation to another. In this way the arsenal can make the most effective use of its man power and the men who learn rapidly have an opportunity to advance themselves within their limitations.

This method when followed out for some time permits the better qualified workers to work on jobs requiring greater skill, leaving the less complicated jobs to the unskilled or semiskilled employees.

The most comprehensive method of upgrading, sanctioned by the Civil Service Commission, is known as the "In-Service Training Plan." Employees for in-service training are carefully selected from those having the necessary basic qualifications and who give promise of developing the required skill in the designation for which they are to be trained. The employee selected for in-service training retains his original designation and rate of pay but works at the job for which he is being trained. When he attains the required skill and the length of service or experience required by Civil Service regulations, he is promoted to the new designation.

At the present time, we have more than 500 employees receiving in-service training and, since January 1, 1941, have advanced some 350 to higher designations as the result of such training. Thus, laborers have been advanced to machinist helpers; machinist helpers to general machine operators; general machine operators to turret-lathe operators, set-up men, and machinists; machinists to armament machinists, production assistants, and inspectors; and production assistants to assistant foremen.

No provision is made for classroom work as with the apprentices, and there is no requirement that men on in-service training do any outside work. However, we have found that many of them avail themselves of correspondence-school courses and night schools.

Training of mechanical draftsmen is conducted in somewhat the same manner as in-service training but is really a combination of the principles of in-service training and of apprenticeship. Here we start with junior messengers who enter the service at $600 per annum and who are assigned to work on the drawing files and as assistants in various ways in the Drafting Division. Those showing aptitude and who have completed successfully a high-school course or its equivalent in mechanical drawing are advanced to the position of apprentice draftsman at $1,260 per annum. The next step is that of junior draftsman at $1,440 per annum.

STILL another method of advancement is afforded through training gained by "incidental assignment." This again is a plan recognized by the Civil Service Commission mainly devised to give credit for experience when an employee may be required to work from time to time on a job other than that pertaining to his specific designation. Unless formally designated to received in-service training and so reported to the Civil Service Commission, an employee, under the rules, may not be diverted from work pertaining to his designation for more than twenty-five per cent of the time. If he is so diverted, a record is made of the time spent. When he has received enough total service in the higher position to satisfy Civil Service regulations and providing a vacancy is available, he may be promoted thereto.

This scheme, therefore, is not so much a system of training as a means of recognizing experience gained when working at a job other than that for which originally employed. It is a happy solution for the Civil Service employee who is too old to be an apprentice and not sufficiently outstanding to qualify for "upgrading" through in-service training.

In conclusion, I believe one of the bright spots that the lean years of the depression has produced is the increased earnestness shown by many young men to improve their workmanship. At the last examination for apprentices we had 1,200 applicants. It is a hopeful sign to witness this diversion of traffic from the overcrowded white-collar class. Once in the service, the man with ambition can march ahead. For the very size and speed of the national-defense program has necessitated a marked emphasis on the upgrading of workers. Never before at the arsenal has the man who is innately industrious and ambitious had a better chance to advance himself. Not only is opportunity knocking at his door, but he is being encouraged and trained to meet that opportunity.

Small-Arms Ammunition

Record Production Speed-Up at Frankford Arsenal

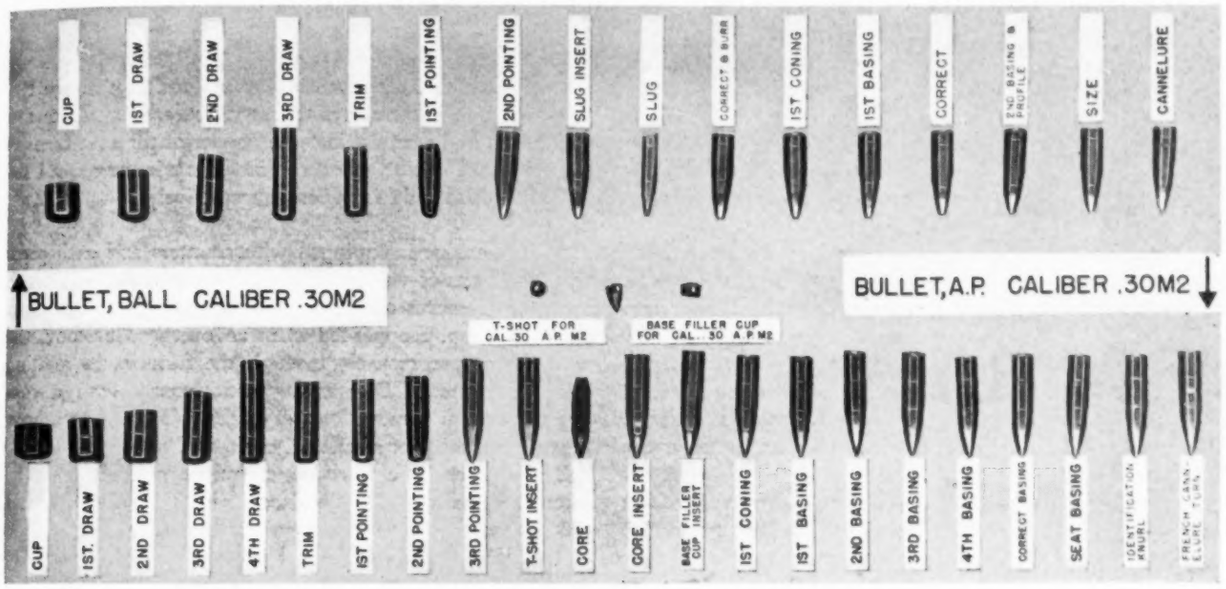
Col. James Kirk *

IN spite of herself, America has been kept up to date and beyond in the development of modern battle equipment by the Ordnance Department of the U. S. Army. Through its various manufacturing arsenals and research laboratories, the Ordnance Department has worked hard through the years to keep the United States prepared to change over swiftly from civilian production to a war basis. Today, these arsenals are not only showing civilian industry how to make war material—they are showing how to get increased production out of their existing plant. The Frankford Arsenal is a high light of real achievement along this line.

In the Small-Arms Division alone, production in this arsenal has been stepped up ten times in as many months, and the ceiling is not yet reached. The rate of output today is already way above the peak reached in the World War. Much of this accomplishment has been with old machines although millions of dollars worth of new ones have been installed. For example, a centerless grinder for smoothing armor-piercing steel shell cores was speeded up to a rate of 30,000 every 8 hours by making a few simple changes, such as hopper feed, etc. Another example is the addition of more dies and punches to old presses, making them do double and triple duty.

In fact, this speeding up of individual machines has been so great, and tools are used up so quickly that the manufacture of such items as dies and punches has been put on a mass-production basis. Machine-tool steel in the form of long rods is swiftly consumed in automatic screw machines. The blanks turned out by these machines are heat-treated and then sent down lines of special grinders where a system by which each operator grinds a single component has been introduced to increase speed and efficiency. After the final polish, these tools pass a most rigid inspection with very few rejects.

In the division where cartridge cases and shells of caliber .30, .40, and .50 are made, hopper feed was applied to all presses, machines, degreasers, and heat-treating furnaces. A high ceiling here permitted the installation of floors or balconies directly above the machines, and all material, raw or in process, is taken there in drop-bottom shop-transfer trucks or elevator conveyors and fed directly into the hoppers. Gone is the litter of tote boxes, helpers, and spilled material. Machines are set closer together—order and precision reigns.



MANUFACTURING OPERATIONS, CALIBER .30M2 BALL AND CALIBER .30M2 ARMOR-PIERCING BULLETS

The small-arms ammunition factory has been put on a 3-shift basis and is prepared to operate seven days a week by means of the swing-shift system. The entire personnel of the arsenal is composed of Army men or those with Civil Service rating. Along with production a large number of men are constantly being trained as supervisors, machine operators, in proof-house technique, etc., not only for employment here but elsewhere as well.

The Small-Arms Ammunition Division at Frankford is self-contained from raw material to loaded cartridge. Raw materials are purchased in large quantities, and both raw material and finished product are meticulously tested in the laboratory. Ball, tracer, armor-piercing, incendiary, and blank ammunition are produced as well as grenades, etc. New ammunition is constantly being designed by the development department and put into production by the engineering division.

The Frankford Arsenal has one of the most completely equipped laboratories in America. Completeness goes so far

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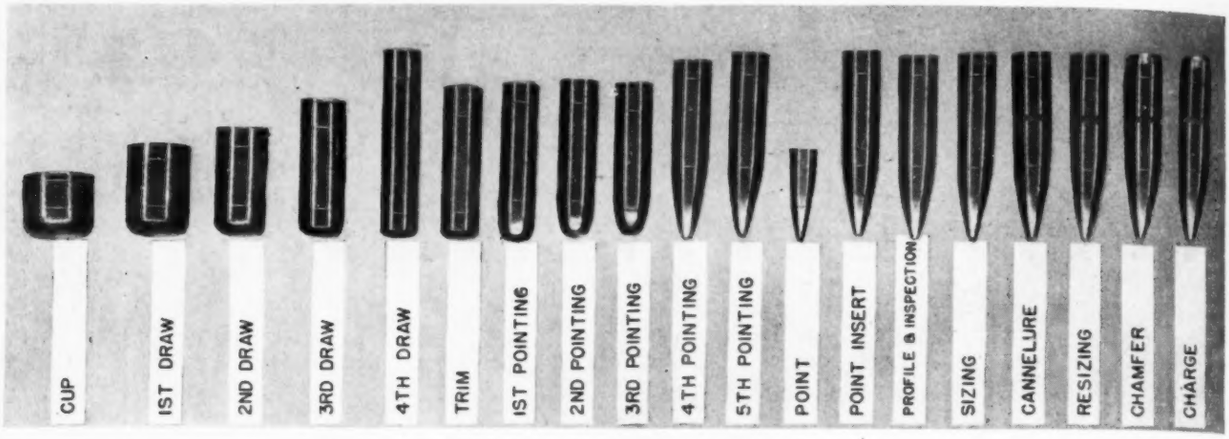


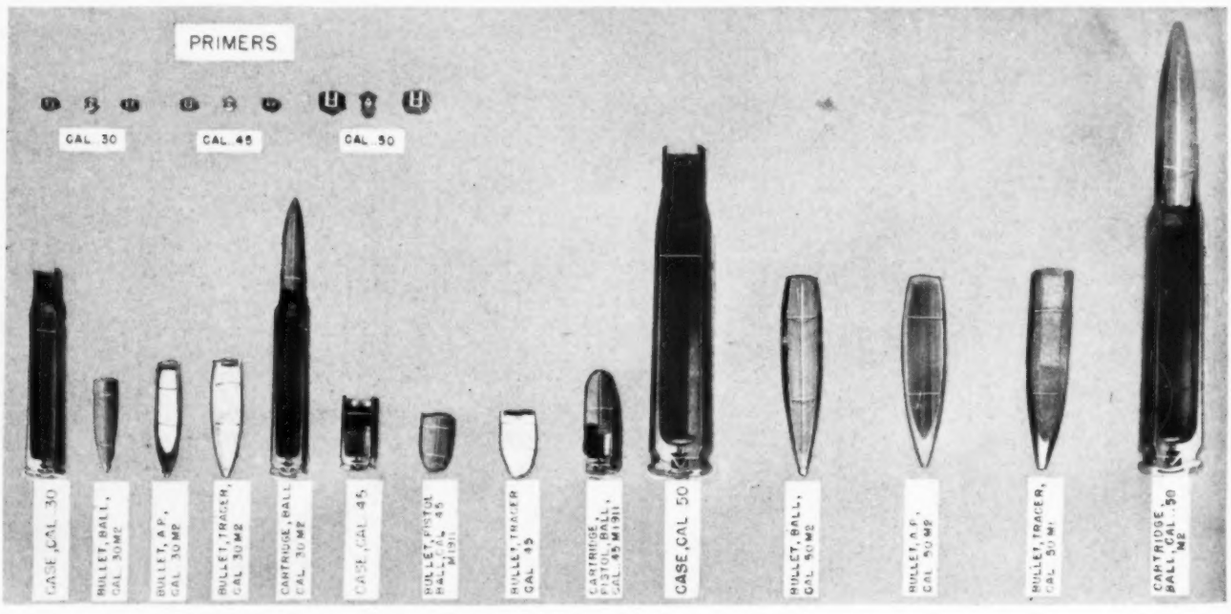
Manufacturing Operations, Caliber .50M1 Tracer Bullet

as to include a production line with all the presses, trimmers, furnaces, etc., for making cartridge cases, so that experimental models can be given full-scale tryouts to speed the perfecting of the final design. High-speed X-ray cameras record the actual progress of armor-piercing projectiles in their travel through armor plate.

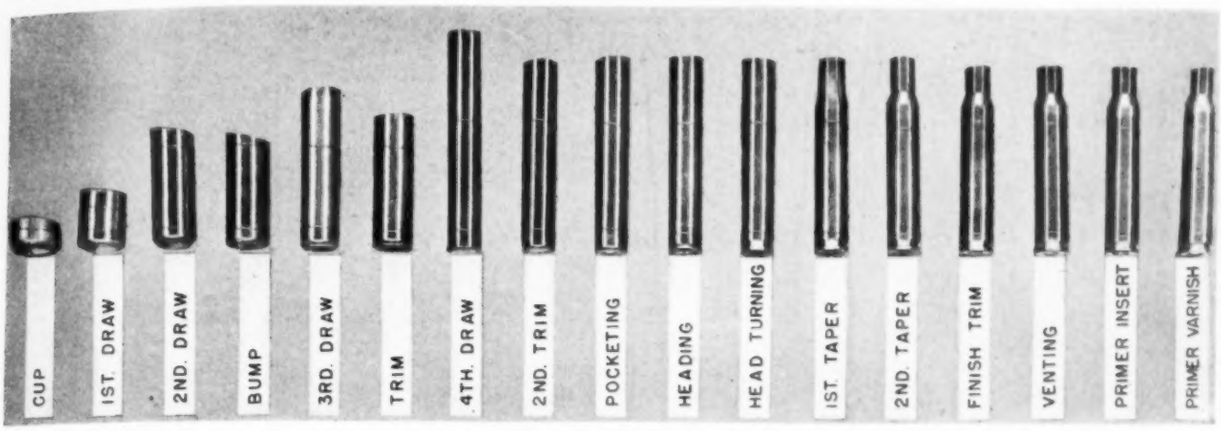
All ammunition is tested in a proof house or on a firing range in the ballistic laboratory for functioning, hangfire, accuracy, velocity, pressure, etc. It is of great importance to have the powder and primer charges in the cartridges of the utmost accuracy; for example, in shooting a machine gun synchronously through a fast-whirling airplane propeller the slightest variation in ignition time would cut off the blades. Thus, a single error in manufacture could cripple an entire flight and lose a battle.

Production starts with the brass cartridge cases. After the blanking and cupping operations, the caliber .30 and .50 cases are given four draws in Bliss and Ferracute presses with an anneal, pickle, and wash after each draw. As already stated, they are hopper-fed from above, but the cases are positioned, open end up, in pin ring wheels, as they drop into the dies. After each operation they are pushed through the dies and drop into transfer trucks which are hoisted to the floor above and dumped into the hopper of the next furnace or machine. The line, of course, includes trimmers, used between the third and fourth draws, respectively.

EACH machine is equipped with counters and each press with three sets of punches and dies in one division. Electric annealing furnaces and washing machines are located in a separate group. Hopper-fed from an overhead balcony, the work passes progressively through the furnaces in rotating cylindrical retorts. Discharging continuously onto a conveyor, the work is moved to and discharged into the washers. A washer consists of a series of perforated steel cones, placed end to end, and the work passes from one to the other by means of rotation in an inclined helix. The cones are partially submerged in tanks of liquid so that the cases receive in succession an acid dip, a water wash, a water rinse and a soap dip for neutralization. The work is discharged into bucket elevators and thence to trucks in the balcony for transfer to the proper presses.


PRIMERS
CAL. 30
CAL. 45
CAL. 50
CASE, CAL. 30
BULLET, BALL, CAL. 30 M2
BULLET, AP, CAL. 30 M2
BULLET, TRACER, CAL. 30 M2
CARTRIDGE, BALL, CAL. 30 M2
CASE, CAL. 45
BULLET, PISTOL BALL, CAL. 45 M1911
BULLET, TRACER CAL. 45
CARTRIDGE, PISTOL BALL, CAL. 45 M1911
CASE, CAL. 50
BULLET, BALL, CAL. 50 M2
BULLET, A.P. CAL. 50 M2
BULLET, TRACER, CAL. 50 M1
CARTRIDGE, BALL, CAL. 50 M2

Sectioned Components of Caliber .30, .45 and .50 Ammunition



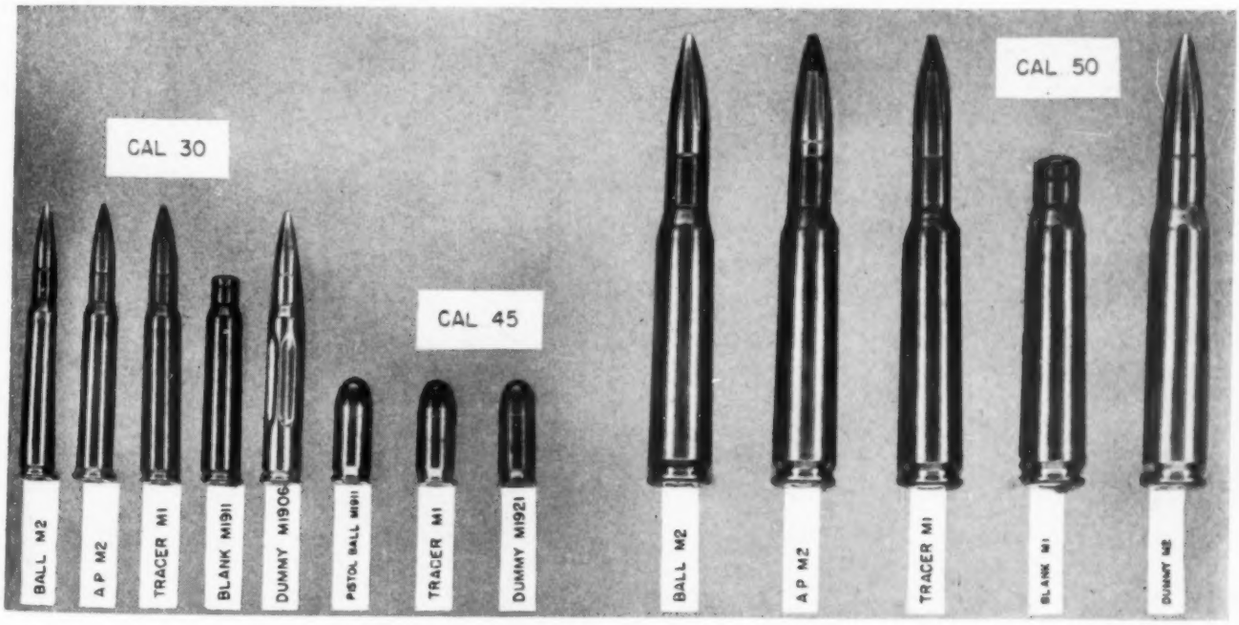
MANUFACTURING OPERATIONS, CALIBER .30 CARTRIDGE CASE

Caliber 5D cases from the last wash and soap dip go to the pocketing and heading press and then to a horizontal 5-spindle machine which turns the ejector groove, faces the head, and chamfers the primer pocket. For chip disposal the machines are provided with air blasts which constantly remove the chips from cutting tools and work. The body anneal is now performed on a rotating circular table with rotating fixtures close to the outer edge. Fed onto these fixtures, open end up, the cases are moved in a circle through a series of flames, back close to the starting point where they are removed by a rotating finger.

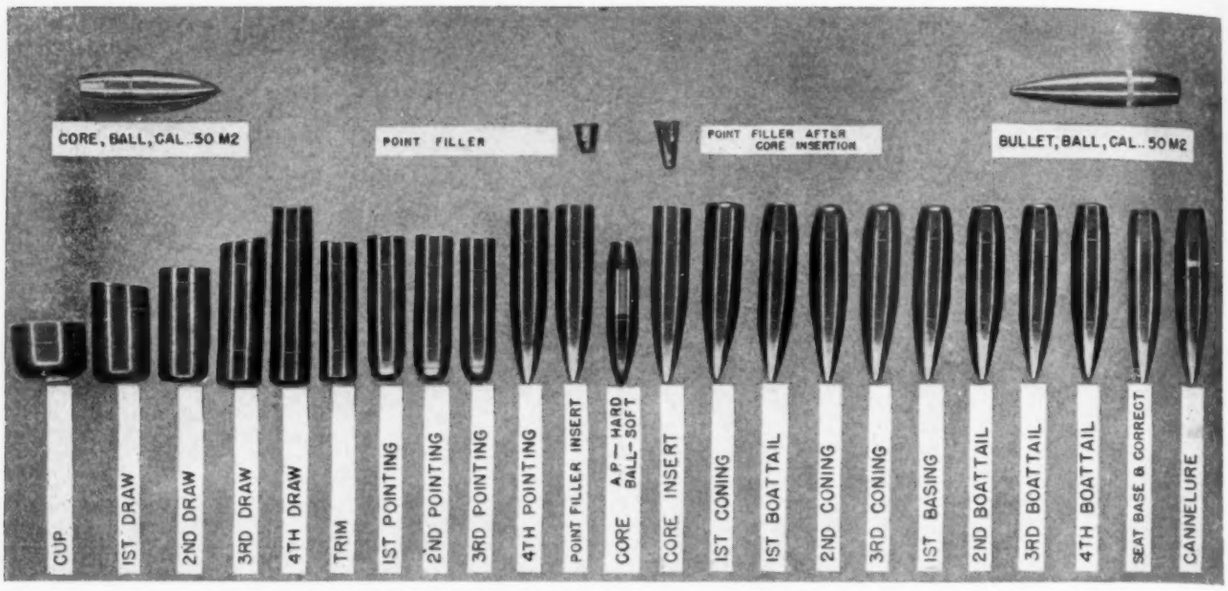
The body taper, neck, and shoulder of these cartridge cases are formed in another press, the mouth is finished, trimmed and chamfered, and the neck is annealed in a device consisting of two rotating worms which move the shells along through a series of flames. They are then transferred to a similar conveyor which carries them along at an angle so that the aspects of both ends are presented, by means of micors, to the inspector. A stop checks the cases for lengths.

There is another machine which has been designed to perform several operations, including inserting the primer in straight-line progression. Fed continuously, the cartridge cases are indexed along by a transfer bar under a series of punches in the head of a modified press. They progressively perform the following operations: check primer pocket, punch flame or vent hole, check vent hole, burr pocket, feed in primer, check for "no primer," seal and crimp primer, and file crimp to smoothness. Finally, a waterproof liquid is put on primer and inside mouth.

ARMOR-PIERCING bullets are composed of a copper jacket ten per cent zinc, a steel core, and a lead filler. The jackets are formed in four draws similar to the cases, but require no anneal. (The tracer jacket has one anneal between the third and fourth draws.) The copper jacket gives softness for the lands of the rifle bore to cut and effect rotation. The lead point filler is necessary to fill the space between the long nose of the jacket and the short nose of the core. It is possible that a plastic filler may be adopted. The long ogive curve provides the most efficient ballistic characteristics to the projectile in flight, while the shorter curve is necessary for strengthening the point for penetration.



COMPLETE CARTRIDGES—CALIBER .30, .45 AND .50



Manufacturing Operations, Caliber .50M2 Armor-Piercing Bullet

Cores of tungsten or molybdenum steel alloy are machined from bar stock in a battery of recently purchased Davenport automatics. These are 5-spindle machines, and as the bars are indexed around from station to station, the nose, body and boat tail are cut with forming tools. The core is cut off at the last station and the bar fed forward the proper amount for the next core. The cores are heat-treated in fuel-fired furnaces of the rotary-drum type equipped with automatic temperature controls. A quenching method has been worked out by which the core strikes the water at an angle insuring submergence without subsequent ricochet. A device at the discharge end of each furnace positions the cores so that they drop at the proper angle. As a long travel through the water is specified, the baskets in the quench tanks are six feet deep.

The point filler is made of a lead alloy (2½ per cent antimony) which is prepared in a separate melting room and poured in 100-pound ingots. These ingots are placed in hydraulic extruders which extrude it into wire which is coiled as fast as it is formed. It is then fed into a swaging machine which shears and forms the fillers in two operations, the excess metal weeping out through the die.

The three components of the armor-piercing bullet are now assembled in eleven operations in a hopper-fed press with a multiple forming die. The work is indexed along from one die cavity to the next by a transfer bar. The operator is protected from broken punches by a safety-glass shield between him and the work.

The jacket is fed first and an exploratory punch checks it for foreign matter. This is followed by four pointing operations in four die cavities. The lead point filler is then fed in, seated, and formed. The steel cores are now fed into the jackets and the entire assembly is formed about the boat tail of the core and closed in seven operations on another press. The cannelure groove for crimping on the mouth of the cartridge is cut last. (In modern practice, this groove is not cut in the steel core but only in the gilding-metal jacket.)

The cups and anvil of the primer are blanked and formed out of strip brass and are washed in inclined rotating barrels. Filling the primers with priming mixture is done in a separate air-conditioned room. A series of perforated plates are employed for holding the primers and the priming mixture, transferring the mixture into the primers, and seating the foiling discs to hold the charge and finally the anvils.

Loading the ammunition requires a series of operations, and an entirely new machine has been developed here at the Frankford Arsenal for this purpose. All the operations are combined in the single machine so as to achieve progressive, straight-line production. It is equipped with three hopper feeds and rotating positioners, a slide guide, and an indexing transfer bar. The cartridge cases come first, open end up, and an exploratory punch checks them for foreign matter. Pushed into a rotating feed dial, the cases are indexed under a powder hopper and the exact charge dropped from a cup on a slide bar. Back on the straight slide, a punch next checks the charge volumetrically. Bullets are fed, nose up, from a profile hopper at the next station, and seating and crimping the case mouth in the cannelure are performed at the two following stations. The last operation is tipping the nose with paint for identification. A circular rotating plate is fitted with a series of slotted guides on the under side and the cartridges, head up, are pushed mechanically between the guides which engage the ejector grooves. The noses of the bullets are then moved mechanically through a paint bath.

Tracer bullets also consist of three parts; namely, a gilding-metal jacket, antimonial lead nose (for ballistic purposes), and an incendiary mixture. A brand-new set-up was designed and built to step up the loading of this tracer mixture. An operator first puts the jacket into a doughnut-shaped steel holder and slides it into a small inclinable press which firmly seats the jacket in the holder. The holder rolls in a slide to another operator who puts on a funnel and sets the assembly on a 10-foot steel band conveyor. While moving along this conveyor a mechanically operated scoop drops in the correct amount of tracer mixture. A punch compresses the mixture to the proper density, a vibrating tapper further settles it, the igniter pellet is added, and another punch gives the load a final compression.

Small-arms ammunition manufacture is but one of three extensive divisions of the Frankford Arsenal. The other two include immense facilities for the development and production of artillery shells and fire-control apparatus.

New Wings for the Army

DESPITE the tremendous problems involved in changing from normal peace-time production to quantity manufacture under emergency conditions, the airplane industry of the United States has swung into stride and now is turning out warplanes for the nation's defense forces at an ever-accelerating rate.

The following figures show graphically the production progress made during the past year: In November 1940, the industry turned out 700 military airplanes. In December, it produced 800. In January 1941, 1,000 planes were turned out; in March, 1,200; in April, 1,427; and in September a new production peak was reached with 1,914 military airplanes. A striking example of this speed-up is the fact that heavy 4-motored long-range land bombers and flying-boat patrol bombers—formerly months in the making—now are rolling off the assembly lines at the rate of better than two a day.

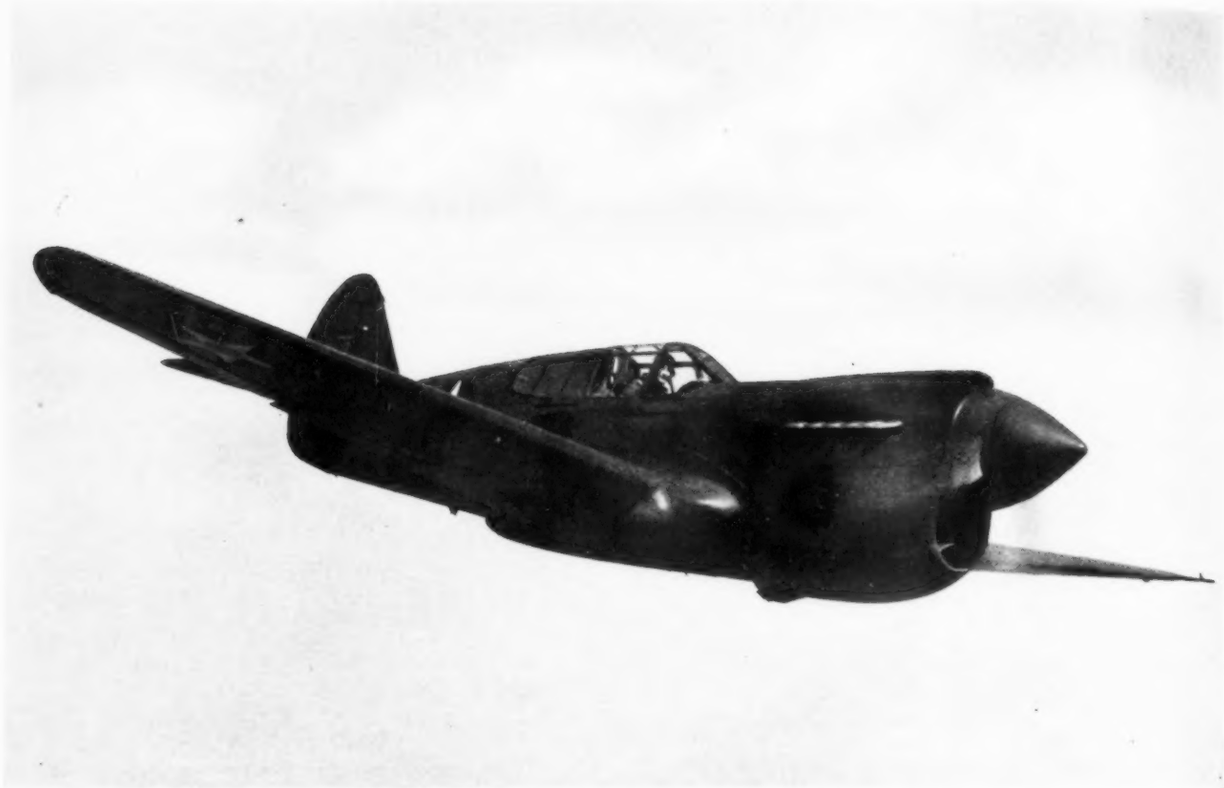
A goal set by defense officials for the aircraft industry is the building of 44,000 warplanes of all types by July 1, 1942. This includes 3,600 multi-engined bombers to be built under the Knudsen plan of utilizing the facilities of the automotive industry in the production of aircraft. It has been estimated that a total of at least 18,000 warplanes will be produced in 1941 and that 30,000 planes will come from the industry's assembly lines in 1942. It is predicted that by the end of 1943 the United States will be turning out 3,600 planes of all categories each month—which also will necessitate the production of 9,000 engines and propellers monthly.

Another idea of the tremendous expansion of the aircraft industry may be gained from the fact that in the 8 months preceding March 1, 1941, the industry's floor space increased 82 per cent—to 31,383,967 square feet. During the same period the total number of aircraft employees increased to 226,172—an increase of 88 per cent. In 1939, the industry turned out planes valued at $225,000,000; in 1940, the output increased to $544,000,000, and in 1941 it is expected that $1,500,000,000 worth of airplanes will be manufactured.

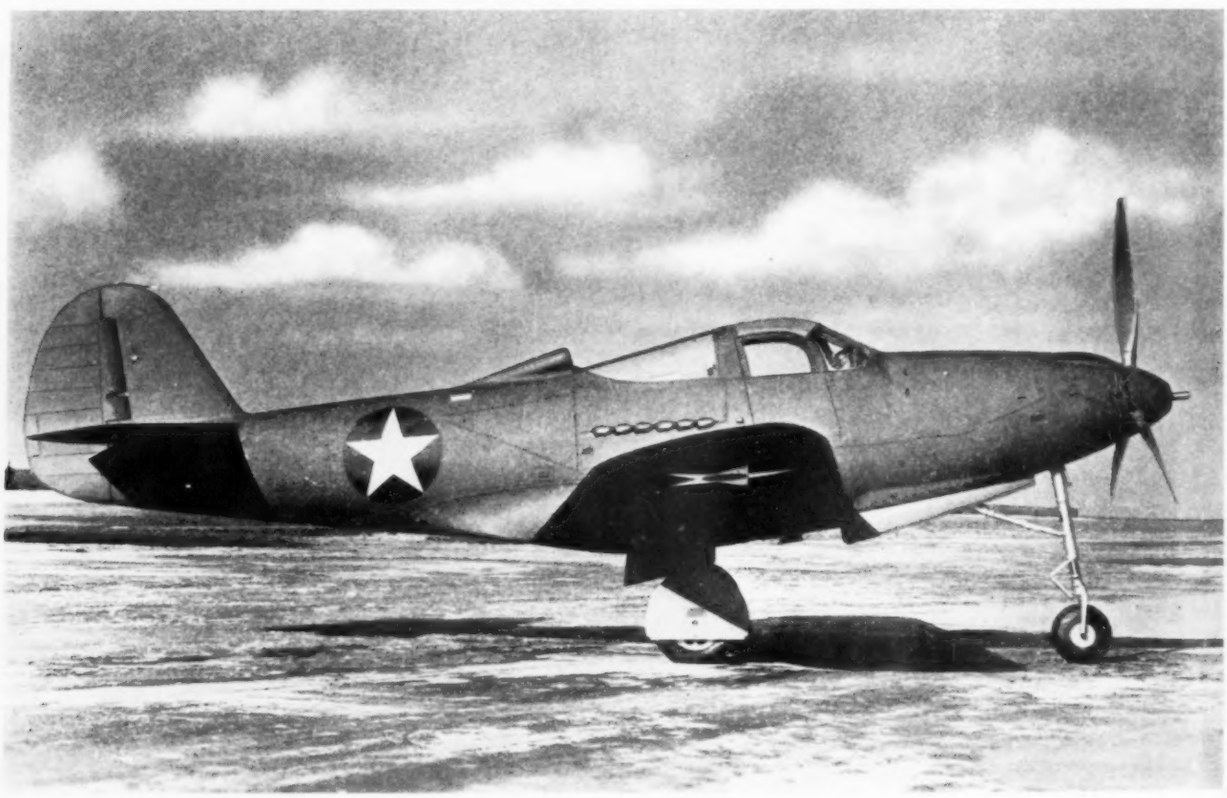
Needless to say, this tremendous increase in production has not been accomplished without a corresponding increase in facilities. Many new plants have been built and practically all existing ones expanded. To meet the Army's increased demand for heavy bombers, ten factories have been scheduled to produce 4-engined planes of this type. Douglas, Consolidated and Boeing each will operate two plants, and Ford, Martin, North American, and Lockheed will operate one apiece. In about a year, the combined output of these plants is expected to be 500 a month.

It would be impossible to turn out these vast numbers of highly complicated military warplanes without modern mass-production methods, and mass production requires the adoption, within certain limits, of standard types. So today, while the U. S. Army continues its research and development activities to find faster, more deadly fighting planes for the Air Force, it has adopted as standard, airplanes so superior to those of other nations that they give this country, qualitatively at least, the finest air force in the world. The following are the principal types of combat planes now in service: A light (attack) bomber—the Douglas A-20; a dive bomber—the Douglas A-24; two types of medium bombers—the North American B-25 and the Martin B-26; three types of heavy bombers—the Boeing B-17, the Consolidated B-24 and the Douglas B-19 now under test; and three pursuit planes—the Curtiss P-40, the Bell P-39, and the Lockheed P-38 interceptor. These and the other types of Army airplanes shown on this and the following pages are from U. S. Army Air Corps photographs.

New Ranges for the Guns



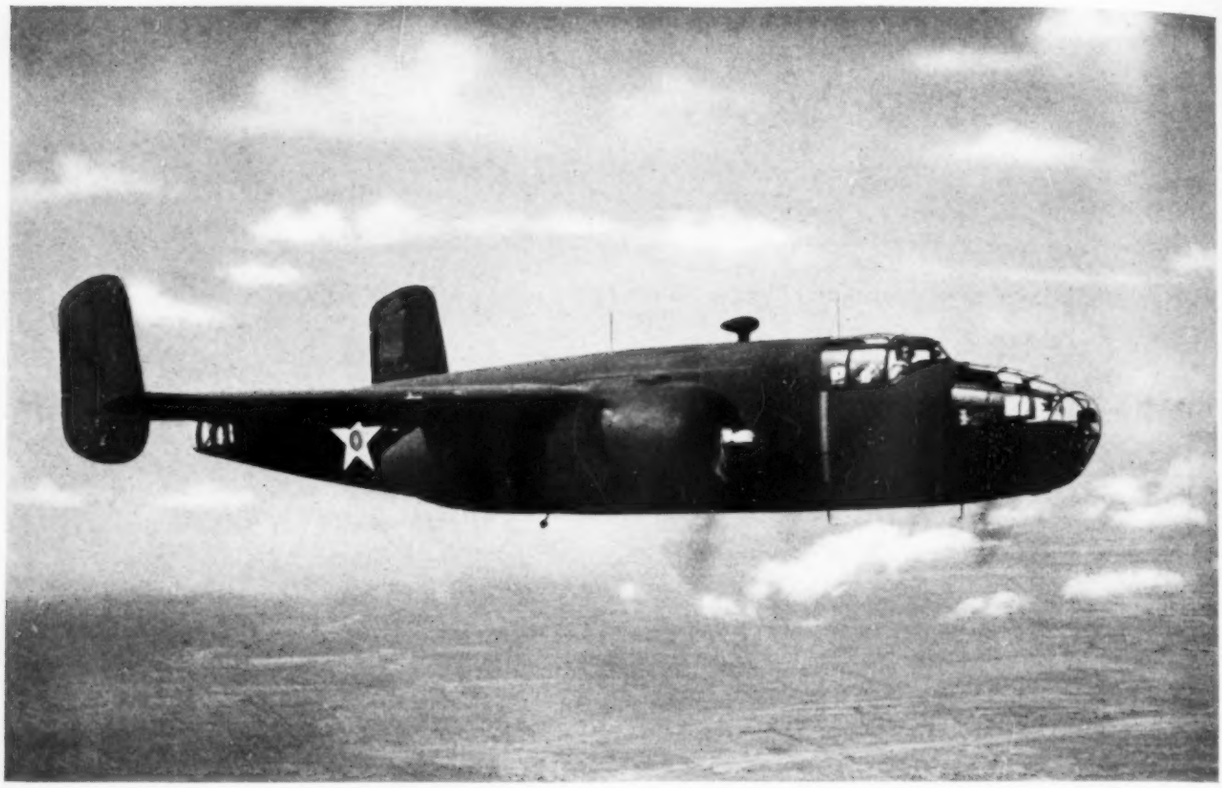
The Curtiss P-40, a fast pursuit ship, above, mounts 6 cal. .50 machine guns. Powered with an Allison liquid-cooled engine, it is equipped with armor and leak-proof gas tanks. The Bell P-39 "Airacobra," below, carrying both cal. .30 and cal. .50 machine guns and a 37-mm. cannon which fires through the propeller hub (see frontispiece) is very effective.



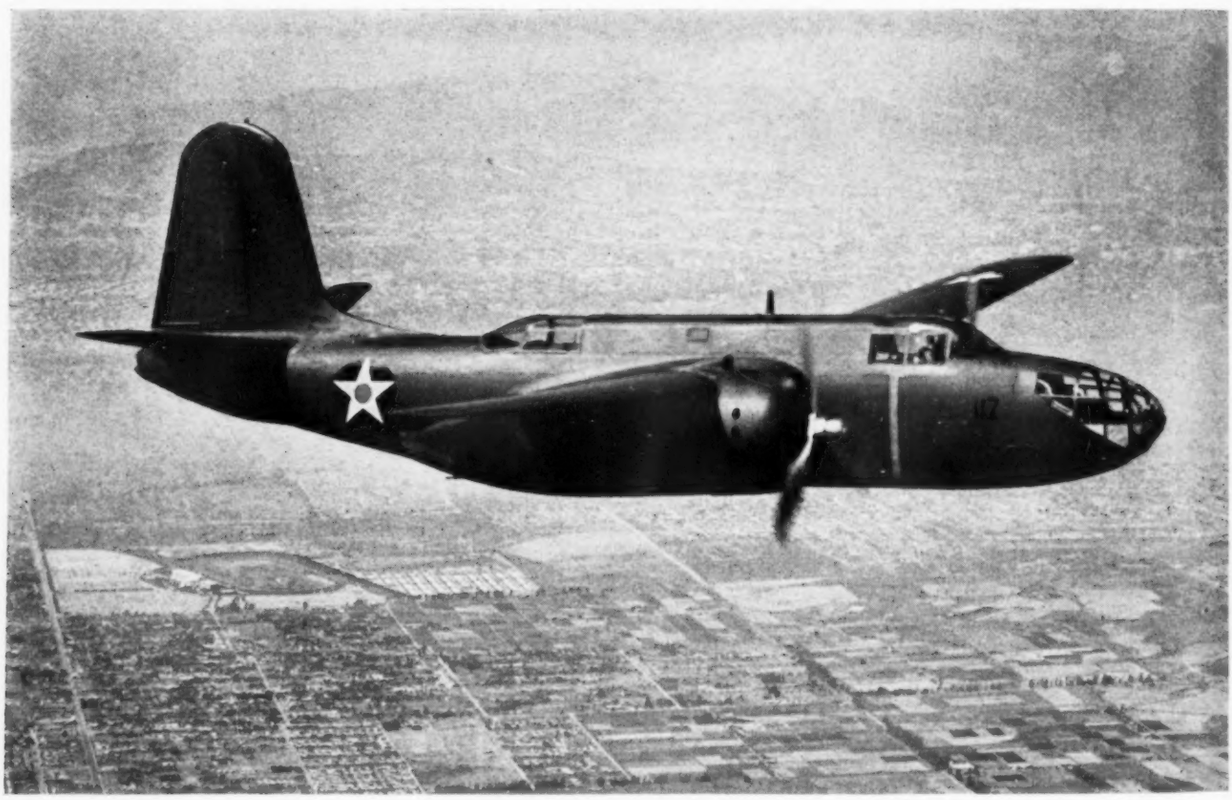
New Speeds for the Projectiles

The Bell P-39, above, is one of the fastest and most heavily armed combat planes. Its Allison liquid-cooled engine is mounted behind the pilot and drives through a long shaft. It is also equipped with retractable tricycle landing gear. The Republic XP-47B, below, a new single-place interceptor plane with a 2,000-horsepower engine, is now being tested.

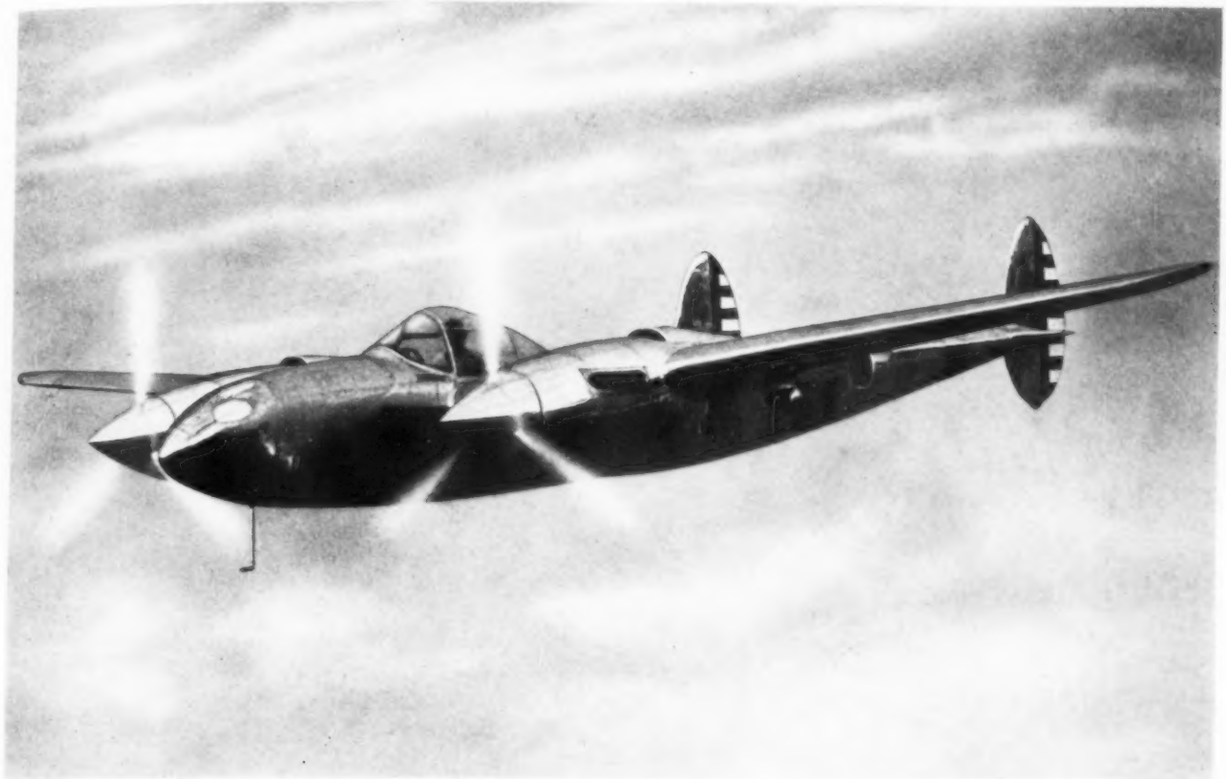
Bombers—Medium and Light



The North American B-25 medium bomber, above, carries a crew of 5 and full radio equipment. It is all metal with an internally braced wing and is powered with two 14-cylinder air-cooled engines. Below is the Douglas A-20 light (attack) bomber. It has a 61-foot wingspan, carries a crew of 3 and has a gross weight, with normal load, of 19,050 pounds.

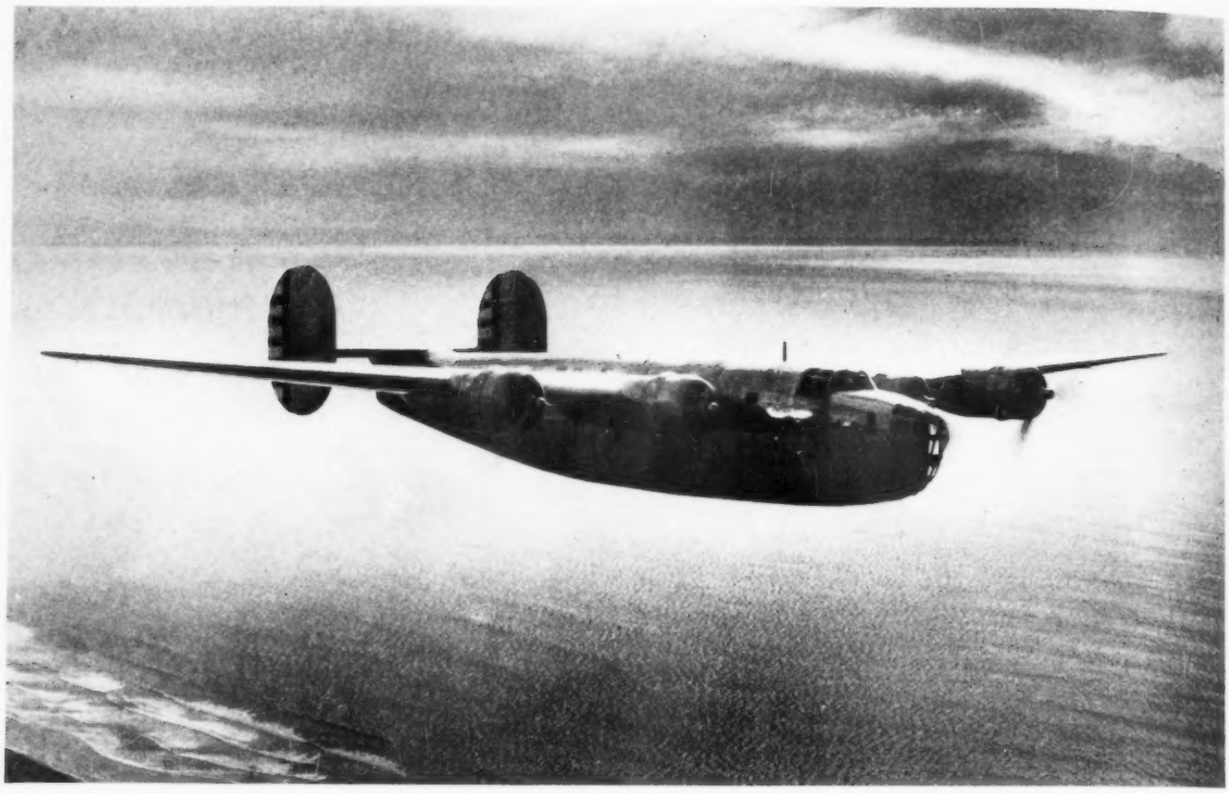


Fastest in Combat and Maneuver

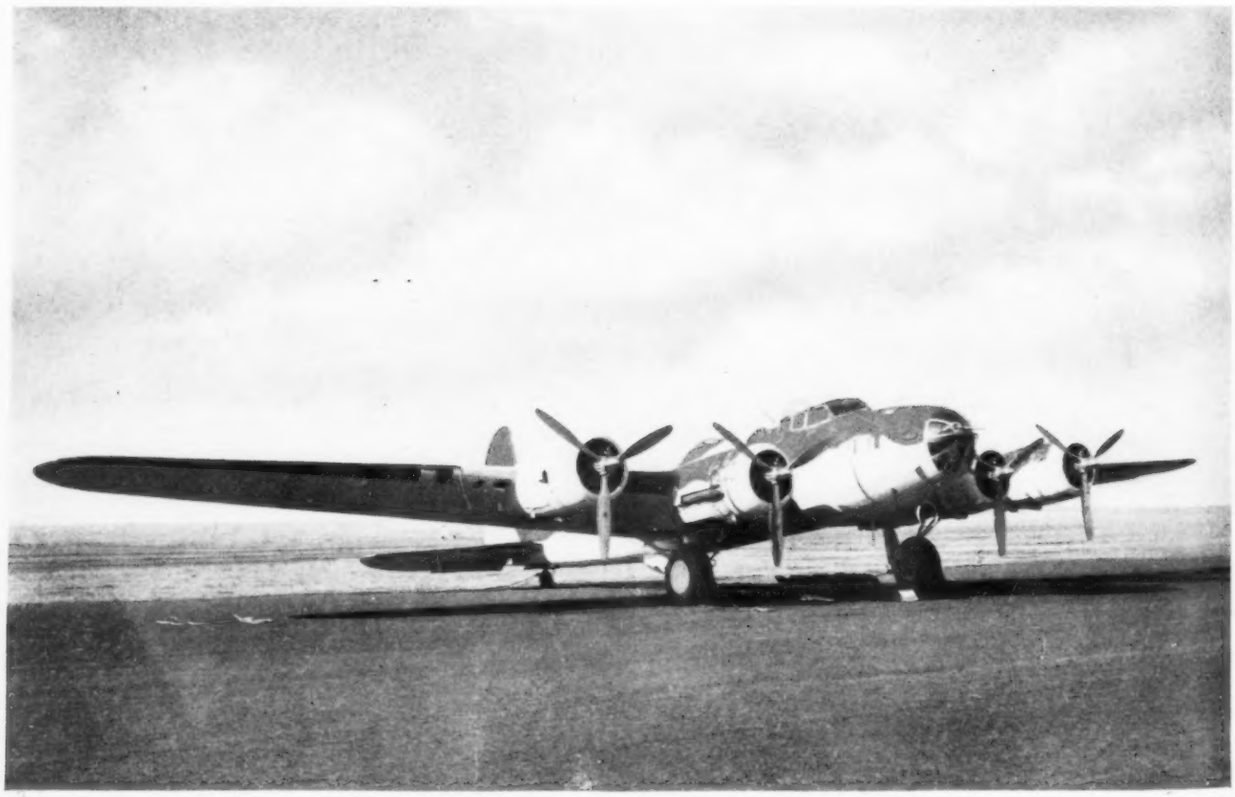


The Lockheed P-38 interceptor, above, is known as "the fastest combat plane in the world." Equipped with 2 Allison 1,000-horsepower engines, the plane mounts 37-mm. cannon and cal. .50 machine guns. The Martin B-26 medium bomber, below, is powered with two 18-cylinder, 1,850-horsepower engines, carries a crew of 5 and has a gross weight of 26,625 pounds.

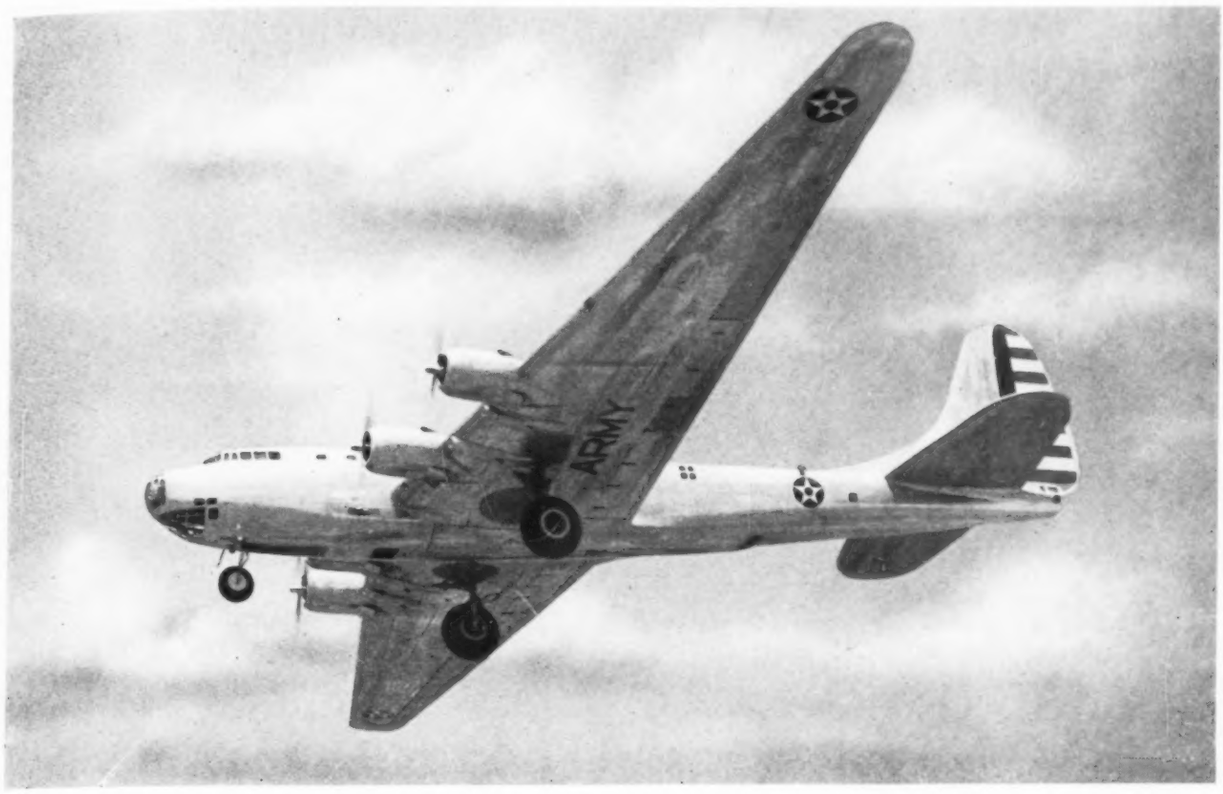
For Distant Bombardment



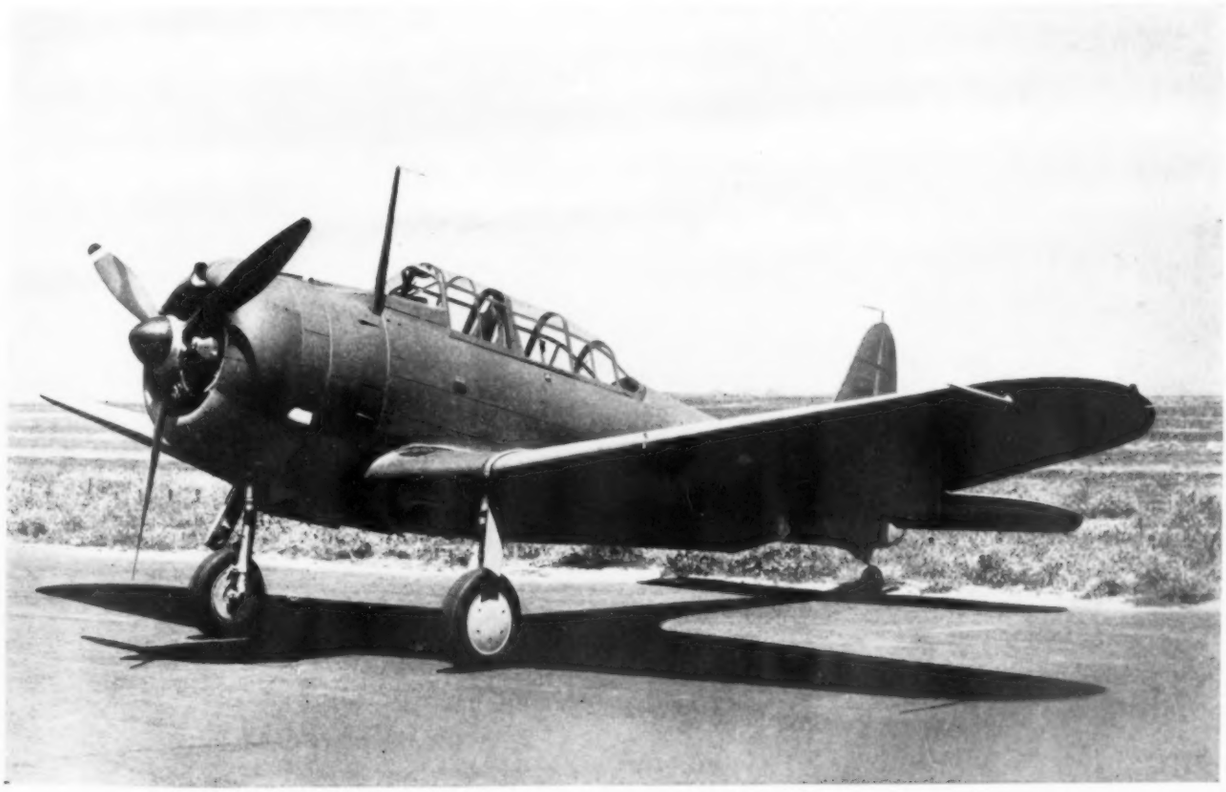
The Consolidated B-24 heavy bomber, above, can climb to 7 miles, fly 300 miles an hour in the substratosphere and carry tons of bombs more than 3,000 miles. The Boeing B-17D "Flying Fortress" heavy bomber, below, is powered with four 1,200-horsepower Wright engines, has a speed of over 300 miles an hour, and carries a crew of 7 to 9 men.



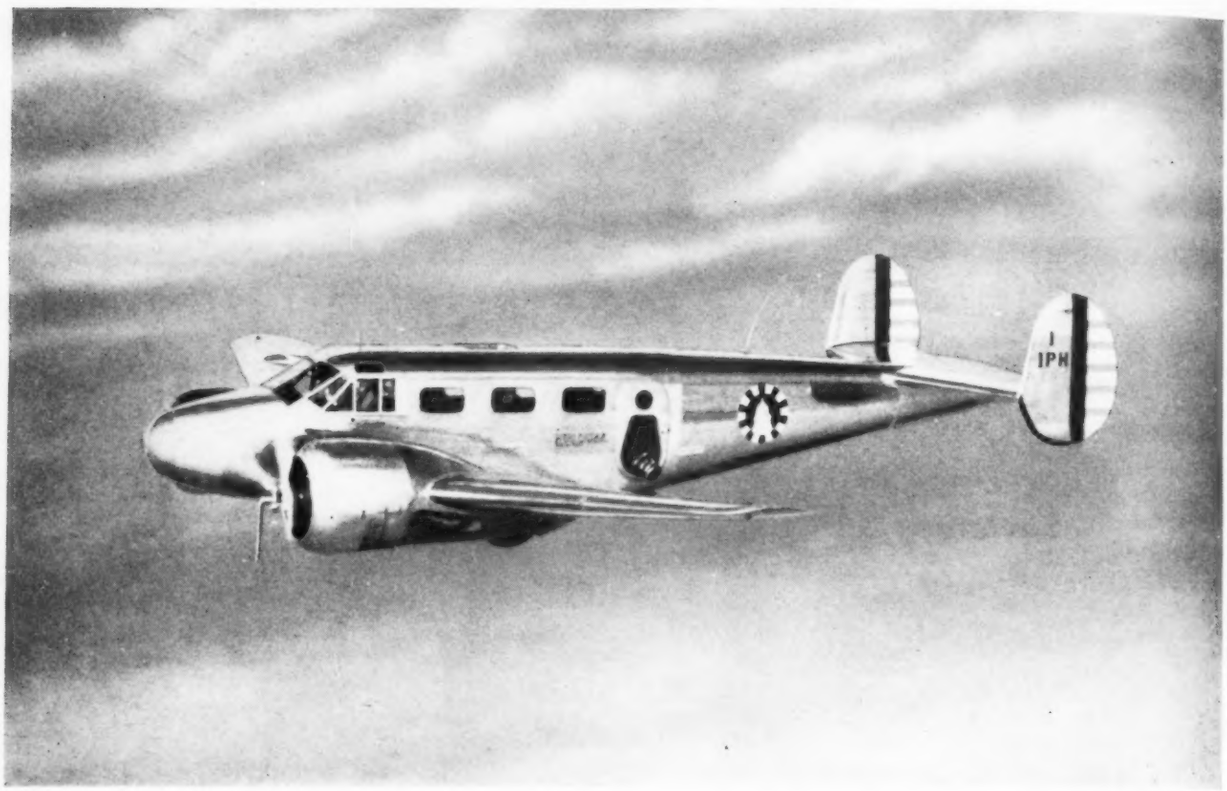
For Long-Range and Dive Bombing



The Douglas B-19, world's biggest bomber, above, is now being tested by the Army. Weighing 70 tons, with a wing-spread of 210 feet, the ship is powered with 4 engines totaling 8,000 horsepower. It has a speed of over 200 miles an hour and a range of more than 6,000 miles. The Douglas A-24 dive bomber, below, is a late addition to the nation's air forces.



For Mapping and Training



The Beechcraft F-2 photographic airplane, above, is used for rapid reconnaissance mapping, tactical mapping, and other types of aërial photographic work. It is the first airplane built to take a tandem mounting of two T-3A cameras. Below is the Cessna AT-8 advanced-training plane used in training advanced pilots on the multi-engined type of combat airplane.

Irregular Warfare

The Rôle of Irregular Troops in Modern Conflict

Hoffman Nickerson*

IRREGULAR war and irregular troops, although in practice are usually found together, are not identical. The former, sometimes known as small war or guerrilla war, is that form of mobile warfare adopted by forces so inferior in fighting power that they cannot meet the main bodies of their enemies in battle. The inferiority may be due to insufficient numbers, equipment, or training, or to more than one of these factors, but the principle is the same.

As they increase in strength, irregular campaigns increasingly resemble regular operations, and at the other end of the scale their weakness drags them down toward the feeble struggles of outlaw bands to resist annihilation or capture by the police. Nevertheless, all irregular operations have much in common. They rely upon evasion for defense, and their action takes the form of brief offensives against hostile detachments—each offensive being quickly followed by another evasion. Guerrillas may act alone or as auxiliaries to friendly troops engaged in regular war. In naval warfare we may compare the substitution of commerce destroying for fleet actions, but here we are chiefly concerned with irregular operations by land.

Irregular troops are fighting men who are neither active members nor reservists of the regular forces of the community. Through their consequent inferiority in discipline, and usually in equipment, their action is ordinarily limited to irregular campaigning. On the other hand, they may try to stand on the defensive behind permanent or temporary fortifications, thus engaging in positional battle. For instance, the patriot irregulars of the American Revolution stood behind entrenchments at Bunker Hill and thereafter until shortly before the action at Trenton. Further, regular troops of high military quality may find themselves condemned by shortage of numbers, equipment, or both, to irregular methods.

Today, both are important because they grow naturally from contemporary political and social conditions. Small war has been widely practiced—in Arabia during the conflict of 1914-1918, in Ireland, in China, and to some extent in Spain. A huge mass of irregular troops is being prepared in England by the training of the Home Guard. Moreover, guerrilla campaigns and irregular troops both have been analyzed by a number of able writers. It is common knowledge that insurrections are considerably counted upon by the English to increase German difficulties in the later stages of the present war. Finally, if the victors in the present struggle, whoever they may be, should systematically monopolize the manufacture of ordnance—as seems possible and even probable—then irregular warfare would be the sole armed resistance open to the vanquished.

At first sight, military students may be tempted to despise small war unduly. Finding guerrilla skirmishing petty and uninteresting, as indeed it is when compared with the great shocks of armies which resound through history, they may underrate its effectiveness in its own smaller field. The secret of that effectiveness lies in the peculiar circumstances of an invading army or one of occupation, and in the possibility of keeping such an army under a considerable strain at small expense.

WE shall better understand the matter if we see the regular soldier as an extension of the policeman—the armed man who keeps order. In normal times in its own country, a legitimate government keeps a reasonable degree of order without great effort. The expense of policing, although often appreciable, is not excessive. Matters may be different, however, in recently occupied territory or for a government confronted by vehemently rebellious feeling. If the spirit of even quite a small minority of active guerrillas remains unbroken and if the population of the districts where these guerrillas operate refuses, either through sympathy or terror or a mixture of both, to betray the active minority to its regular opponents, then normal police methods will not pacify those districts. The forces of order must be at the same time numerous and widely distributed, like policemen on a great number of fixed posts throughout a large city, so that they are tempting targets for guerrilla bands which would be contemptible opponents if only a few of the scattered posts of occupying troops could be concentrated against them. By that time, however, the guerrillas have saved themselves by flight, or have blended into the population. " 'Tis only a 'dah' and a Snider that makes a dacoit," said Kipling's Private Mulvaney; "Widout thim he's a paceful cultivator, and felony for to shoot."

If the active minority cannot be promptly stamped out and if the population can neither be cowed nor conciliated, the process may last a long time, during which time the occupying power is subject to expense and to a certain moral strain. Throughout the guerrilla districts the enemy has not yet achieved the advantageous peace which was his object in beginning the invasion or repression. In a few cases, irregular warfare alone has gained victory; the enemy has found the game not worth the candle and has retired. More often guerrillas have made useful diversions, compelling the enemy to use against them forces which would otherwise have been free for operations against the regular allies of the guerrillas.

By this time the reader has doubtless seen for himself the congruity between irregular warfare and the circumstances of our time. Our revolutionary age is one of violent popular passions, encouraged for generations by the philosophy and literature of romanticism and "realism" which agree in exalting animal instincts and emotions. In turn, these emotions are furiously stimulated by systematic "propaganda." Consequently, in spite of the complexity and power of modern weapons—a point to which we shall presently return—guerrilla fighting must be seriously considered. Even when powerful fire extinguishers are plentiful, masses of combustibles may cause considerable fires.

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*Author: "The Inquisition, A Political and Military Study of Its Establishment," 1923; "Warfare" (with Spalding and Wright), 1925; "The Turning Point of the Revolution," 1928; "The American Reich," 1930; "Can We Limit War?" 1934; "The Armed Horde," 1940. First Lieutenant, New York National Guard, 1916; Captain, Ordnance Department, U. S. Army, 1917; duty with General Staff, A.E.F., 1918. Member U. S. Section, Inter-Allied Armistice Commission, Spa, Belgium, 1918-1919.

THE first conspicuous guerrilla of our time was the strange man known as Lawrence of Arabia. The Arab Revolt of 1916-1918 owes its fame not so much to its intrinsic importance as to this perverted but able individual with his combination of learning and literary power.

Up to 1914, the Turkish Empire had included not only the fertile country of Syria but also a broad coastal strip of desert Arabia eastward from the Red Sea. This region is called the Hejaz. A British army—pursuing a doubtful strategy, for if the Turks merely had been fended off from the Suez Canal they would have done the Allied cause little harm in other theaters—was attempting to invade Syria from Egypt. The Arab revolt against the Turks acted first as a sort of diversion in favor of this army, next as a semidetached eastern wing coöperating with it. Since the entire campaign was a sort of side show to the Western Front, Lawrence and his Arabs were a side show of a side show.

Lawrence's means of evasion consisted of the desert mobility of the Arabs—thanks to their mastery of camel transport. The Turks—brave but stupid fighters—possessed a single line of railroad which ran for about 750 miles south and then southeast from Damascus and, in its latter course, about 150 miles eastward from the Arabian coast of the Red Sea to the Moslem holy city of Medina. Strategically, Lawrence's talent lay in seeing that at Medina, which the Turks wished to hold for reasons of prestige, they would be helpless if the railroad, their life line, were sufficiently bedeviled without being permanently cut. The handful of Arab rebels, without appreciable loss to themselves, would achieve maximum effectiveness in favor of the British if they pushed northward up the eastern shore of the Red Sea, occupying little ports to which the British fleet could bring supplies, executing quick raids against the railroad and then escaping into the desert.

The permanent military interest of Lawrence's "Seven Pillars of Wisdom" is concentrated in the passages in which he analyzes this strategy of his and contrasts it with the Napoleon-Clausewitz-Foch method: ". . . The aim in war. The books gave it pat—the destruction of the armed forces of the enemy by the one process—battle. Victory could be purchased only by blood. . . . As the Arabs had no organized forces, a Turkish Foch would have no aim? The Arabs would not endure casualties. How would our Clausewitz buy his victory? . . . However . . . these wise men must be talking metaphors; for we were indubitably winning our war. . . . Out of every 1,000 square miles of Hejaz 999 were now free. . . . The Foch war seemed an exterminative variety, no more absolute than another."

The Turks could only hold such Arab territory as they physically occupied in some force. Thus "they would need 600,000 men to meet the ill-wills of all the Arab peoples, combined with the active hostility of a few zealots. How many zealots could we have? At present we had nearly fifty thousand. . . . If we realized our raw materials . . . , climate, railway, desert, and technical weapons could also be attached to our interests. . . . In Turkey things were scarce and precious, men less esteemed than equipment. . . . The death of a Turkish bridge or rail, machine or gun or charge of high explosive, was more profitable to us than the death of a Turk. . . . Battles in Arabia were a mistake, since we profited in them only by the ammunition the enemy fired off. . . . We could follow the direction of Saxe and reach victory without battle. . . . We were richer than the Turks in transport, machine guns, cars, high explosives. We could develop a highly mobile, highly equipped striking force of the smallest size, and use it successively at distributed points of the Turkish line, to make them strengthen their posts beyond the defensive minimum of twenty men. This would be a short cut to success."

Later in the campaign, when supporting the British attack from Egypt against Palestine and Syria ". . . our operations of development for the final stroke should be like naval war: in mobility, ubiquity, independence of bases and communications . . . we commanded the desert. Camel raiding parties, self-contained like ships, might cruise confidently along the enemy's cultivation frontier, sure of an unhindered retreat into their desert-element which the Turks could not explore."

FOR some time after 1918, the English writer, Liddell Hart, moved both by the lucidity of Lawrence's thought and by the latter's considerable measure of success, argued that future wars would be fought chiefly by "superguerrilla" methods. Invading armies, so he thought, might find themselves delayed by "motor guerrillas" armed only with rifles and machine guns, while anyone who could fly an airplane might usefully act as an "air guerrilla," dropping bombs on hostile cities. As these lines are written, Liddell Hart's predictions have not been fulfilled. Only the motorcycle advance guards of the German armored divisions have remotely resembled his motor guerrillas. No air guerrillas have appeared; and had they done so, they would have been easy prey for a microscopically inferior number of trained pursuit pilots. A New York *Herald-Tribune* editorial of June 18, 1941, recognized small war as the resource of the weaker, as follows: "From the Rhineland to Syria . . . the British are making a concerted movement . . . to exploit the situation . . . and put the most spokes in the wheels of the Nazi timetable. This is the whole art of that type of guerrilla war to which the British have been constrained." Moreover the whole idea of substituting "superguerrilla" warfare for regular operations was from the beginning attacked as unsound because it could not possibly gain a quick decision, and in a twentieth-century conflict, with both sides fully mobilized, a postponed decision means that there will be no true victors, only various degrees of losers.

We now turn to two appearances of irregular troops—in the Irish Insurrection of 1919-1921 and in the Spanish Civil War of 1936-1939—both of which vividly illustrate Clausewitz' axiom that war is not a thing in itself but a phase or subdivision of politics.

The Irish Insurrection was made by a small number of active Rebels who, except in the northern province of Ulster, enjoyed the passive support of the people. Those few Rebels were ill-armed and could hope for no foreign support except through the sympathy of certain minority groups in America. They had only small resources for the purchase of weapons and none for their manufacture. The English Government, undistracted by hostilities elsewhere, made every effort to prevent gun running. All told, therefore, the Rebel activities in themselves did not greatly differ from those of criminal bandits.

The reasons for the British surrender to such feeble foes were almost exclusively political. In general, English people shrink from the exercise of conscious and obvious cruelty, and large sections of English opinion were disgusted by the harsh logic of the repression in Ireland. Further, England had but just escaped from the strain of the World War. It

was said at the time that the governor of the Bank of England, Montagu Norman, urged that British finances should no longer be strained by the expense of the army of occupation acting against the Rebels. Since American coöperation in the international field was desired, the influence of the Irish-Americans upon U. S. policy was feared. Nor must the courage and fanatical devotion of the handful of active Irish Rebels be forgotten. As a result of these converging forces, shortly after a bombastic speech by a prominent English politician in which he said that repression would continue "until we have taken the last arm from the hands of the last Rebel," the British Government abjectly surrendered and established the Irish Free State.

THE Spanish case tells in precisely the opposite direction. Any widespread civil war in Spain—given the sparse population of that country, especially on the harsh central plateau —would seem likely to result in abundant small war because most of the respective fronts must be thinly held. Moreover, the very word "guerrilla" is Spanish, and the Spanish guerrillas who acted against Napoleon accomplished more than any nineteenth-century practitioners of small war. Nevertheless, irregular operations were little seen in Spain from 1936 to 1939 and did not affect the final result.

The chief reason for this superficially astonishing fact was the wise policy of the eventually victorious side—the Nationalists. Although from beginning to end the Red combatants in Spain, except for the considerable forces known as the international brigades, were ill-disciplined militia, they constantly offered battle to their opponents and were unable to supplement their military effort by means of small war. Shortly after the beginning of the struggle, General Mola, then commanding the northern Nationalist forces which were moving southward against Madrid, proposed a beginning of irregular warfare from within against the Red defenders of that city, announcing in a phrase, since famous, that the advance of the four Nationalist columns from outside would be supplemented by the insurrection of a "fifth column" of Nationalist sympathizers inside the place. If such an effort was made, it failed, and thereafter the Nationalists, partly no doubt from necessity but also from deliberate choice, refrained from exposing their friends in Red territory by urging those friends to harass the Red rear areas.

At the same time they took pains to deny to the Reds the possibility of harassing their own rear. Possessing small but well-disciplined regular forces and with most of the regular officers corps available to command and train their irregular levies, they were almost always able to defeat the Red militia in combat. Their one considerable check was that of their advance upon Madrid in 1936, and in that case they seemed not to have tried to push home the attack on finding resistance appreciable. In general, they could have advanced more rapidly than they did, had not Franco, their able commander in chief, recognized that Red guerrilla warfare was the chief danger to his final success. In other words, he saw that it would be a mistake to go forward before thoroughly pacifying each newly occupied district.

The task was not as great as casual newspaper readers in the English-speaking countries might have imagined. The left-wing Spanish government (grandiloquently called "Loyalist" by English and American correspondents!) had, in fact, gained office by wholesale fraud and enjoyed no general and active consent of the governed. Its partisans were chiefly from sections of the proletariat in the great towns and in certain degraded industrial districts. The horrible orgy of Red crimes which immediately preceded and followed the outbreak of civil war was the work of a small minority of agitators. Moreover, those crimes disgusted moderate people. Accordingly the epic march of the little Nationalist "Army of Africa" from Spanish Morocco via Badajos and Toledo to the gates of Madrid was at no time hindered by guerrilla action against its communications.

After the pause which followed their check at Madrid, the Nationalists began their gradual but steady advance and pacification of the country. Ordinarily, as soon as the Reds had been driven from a village, Nationalist welfare workers would bring food and begin to distribute it. The heaps of filth characteristic of Red administration would be cleaned up. A traveling bank would reëstablish monetary circulation. Necessary rebuilding would be begun promptly. The desecrated churches would be reconsecrated and services resumed. All this of course was accompanied by a certain amount of severity. The more prominent Red criminals were tried by court-martial, but considerable efforts were made to see that they were fairly tried, and those executed were killed cleanly without the tortures in which the "Loyalists" (!) so often indulged. The main thing, however, was the constructive side of the pacification, and the process worked so well that normal police methods soon sufficed to keep order in practically all districts conquered by the Nationalists up to the final and wholesale Red collapse in the spring of 1939.

In the regions which he gradually occupied, Franco so thoroughly won his peace in the very midst of war that Red guerrillas, in spite of all their efforts, failed to disorganize his rear because the masses were content with the decency and order which he reëstablished.

AMONG recent examples of irregular war and irregular troops, the largest and most conspicuous is the Chinese resistance to the Japanese—now in its tenth year.

Throughout, the Japanese have been so superior in equipment and in numbers of regular troops that they have been able, without any serious check, to occupy successively Manchuria, the northern part of China proper, and large coastal areas in the south. On the other hand, their difficulties have been the size of the country, the enormous numbers of its people, its largely decentralized, semi-agrarian economy and primitive communications—above all the persistence of a widespread spirit of resistance.

The Chinese guerrilla warfare has been intelligently organized and directed. In the distant past, when soldiers were more esteemed in China than during recent centuries, there was a considerable Chinese military literature, of which the most famous book, "The Art of War" by Sun Tzu, written about 500 B. C., is still read for its principles of leadership and strategy. In addition to this ancient work, Lawrence's "Seven Pillars of Wisdom" also has influenced certain important Chinese commanders. The latter criticize the Japanese for a mechanical, routine application of methods learned by rote—somewhat as Lawrence did the Turks and Germans of his day.

Thus based upon a broad foundation of theory, the Chinese leaders, and especially the Communists, have thoroughly worked out the principles of their action. Irregular warfare, they admit, cannot by itself be decisive. To succeed at all, it must enjoy popular sympathy, with all that that implies in solving the problems of supply, however imper-

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IRREGULAR TROOPS MUST OPERATE AWAY FROM BASES

fectly, as well as in knowing the enemy's movements while concealing one's own. The army, they say, is among the people like a fish in the sea. Its strategy depends upon the guerrilla axiom of never offering opponents a target. As they put it: "When the enemy attacks, we withdraw. When he halts, we harass. When he is exhausted, we attack. When he retreats, we pursue."

As instruments of this strategy they have three separate categories of troops: first, the Communist Eighth Route Army composed of regulars; secondly, full-time volunteer mobile units of irregulars; thirdly part-time irregular Home Guard units, seldom if ever expected to operate far from their villages. The members of these last groups spend most of their time in ordinary peaceful occupations.

The action of the first two groups is usually that of the "short attack," made always with the expectation of completely surprising the Japanese, quickly broken off if not promptly successful, and invariably followed by rapid retreat whether the operation has been successful or not. Even the Eighth Army regulars ordinarily use guerrilla tactics and avoid pitched battles, partly because of the great Japanese superiority in heavy weapons, partly to economize their trained men. Eighth Army "short attacks" are considered failures if the losses suffered exceed ten per cent of those inflicted on the enemy.

On the other hand, detachments of the Eighth Army sometimes engage in regular warfare by holding scattered strategic points, when these points are naturally defensible, in order to draw the Japanese into attacking over terrain in which their rear can be effectively harassed.

The savagery usually characteristic of irregular warfare is prominent in the activities of the Chinese Reds. Naturally, the propaganda used to incite the ignorant and illiterate peasants against the Japanese does not make for civilized military conduct. When the Eighth Army takes a town it is said to be their practice to exhibit their officer prisoners before a public meeting composed of the inhabitants and soldier prisoners assembled in the market place. The people and soldier prisoners are then asked whether they have any charges to make against any of the officer prisoners, and the latter, if "found guilty" of brutalities, are—in Ludwig Renn's typically left-wing phrase—"dealt with." The inevitable results of this sort of thing are obvious. Further, any Chinese peasant not doped by propaganda might find it difficult to distinguish between "patriotic" guerrillas and bandits pure and simple.

The largest number of irregular troops recently organized, and perhaps the largest number ever organized, is the British Home Guard. Its function differs from that of guerrillas in that it is intended to engage in regular operations, supplementing the action of British regulars against a possible invasion of the British Isles. It would be expected to give warning of the appearance of invaders and to crush advanced German detachments—or at least to delay them until defending regulars could appear. Accordingly it resembles the Arab, Irish, Spanish, and Chinese irregulars chiefly in its nonprofessional character and in the imperfection of its armament. To the matter of modern irregular armament, we shall return in a moment. Meanwhile we may also note that the British Home Guard, although patriotic instead of subversive in purpose, is not wholly out of contact with the revolutionary ideas characteristic of our time, inasmuch as Tom Wintringham, chief instructor in the Osterly Home Guard Training School, is a militant socialist who devotes a considerable part of his training booklet, "New Ways of War," to arguments in favor of the confiscation of private property in England. He himself commanded a battalion in one of the international brigades which fought on the Red side in Spain, and his subordinate instructors at Osterly served under him there.

TURNING to the possibility of general anti-German guerrilla warfare on the Continent should the present war be prolonged, obviously the most calculable element in that prospect would seem to be that of armament. On this, the case of Lawrence in Arabia throws little light. His revolt was never cut off from British aid by sea, while it might be impossible for the British to give direct support to Continental revolts, especially in their critical opening stage, except by air.

On the other hand, the Spanish and Chinese cases, together with Wintringham's published recommendations for the English Home Guard, give us valuable hints.

The problem is this: if allies from outside—in this case the British—can send in only small quantities of arms and munitions to nourish a rebellion, what sorts of weapons will be best? Also, what types of weapons effective in modern warfare can be smuggled into a district—"bootlegged" as it were? What kinds can be locally manufactured in secret or adapted from civilian implements before the beginning of a revolt, and what arms can be hastily made when the revolt has gained enough headway to command the free use of a little industrial machinery?

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GUERRILLA FIGHTERS MUST BE AMPHIBIOUS

OBVIOUSLY, the disadvantages of irregular armament are greater than ever before in history. Never have the tools of peace been so differentiated by specialization from those of war. The size and complexity of modern factories; the complexity, precision and power of modern weapons; the number of raw materials required to make those weapons—all tell against rebels. Other circumstances, like the rapidity of contemporary communications and the enormous power of contemporary governments over their subjects, have the same effect. Only the airplane and the submarine, with their powers of evasion, to some extent work in the opposite direction, facilitating the arming of guerrillas by foreign friends.

Artillery and other heavy weapons are of course ruled out. Glancing back at the cases which we have examined, the Chinese guerrillas have trench mortars, fairly accurate up to fifteen hundred yards and comparatively easy to make since they are smoothbores. In point of small arms, most of the Chinese Home Guardsmen carry pregunpowder weapons—swords, pikes, and clubs—supplementing these with a few flintlock smoothbore muskets and still fewer modern rifles. They also have a few crudely made submachine guns, but most of these are useless for want of ammunition. The Spanish Reds, according to Wintringham, also made "simple" submachine guns, copying captured specimens.

The easiest of modern weapons to manufacture is the hand grenade. Even the Chinese Home Guards are abundantly supplied with them, they were liberally used in Spain, and Wintringham gives specifications for homemade varieties. Although their effectiveness is limited by their short range, nevertheless large ones will stop a tank if their users can get close enough to it to make them burst under its lightly armored belly.

On the same condition of getting close to the tank—for instance, when the latter is approaching a road block or passing through a village—then even simpler devices may disable it. Its tracks may be jammed by stuffing a blanket between them and the bogie wheels which carry them, and if the blanket be soaked in gasoline and lighted, the rubber treads of the bogie wheels may be seriously damaged. A sidewise blow from a pickaxe may break the track. More rarely, gasoline poured over a tank or thrown in glass bottles which break when they strike the latter's armor may make a fire hot enough to disable the crew inside.

Shotguns are slightly longer ranged weapons than the hand grenade, and Wintringham suggests ways of making small-shot cartridges for them into man-killing slugs.

Of weapons which could be sent in small quantities into a country or could be smuggled in, probably the most useful would be submachine guns and reasonably foolproof automatic rifles and light machine guns.

It goes without saying that forces armed only with improvised and smuggled weapons cannot develop first-class fighting power. This brings us back to the difficulties of an army of occupation and to the underlying political question. To try to anticipate the part which may be played by insurrections in German-occupied territory and perhaps in the Axis countries themselves would require the gift of prophecy and will therefore not be considered here. We need only mention that, as these words are written in August 1941, the activities of Russian guerrillas against the German armies in that country are frequently reported.

PARADOXICALLY enough, it seems a little easier to look into the more distant future which will follow the end of the present war. Whichever side wins, it will probably monopolize the manufacture of ordnance, doling out to the defeated side only just enough weapons as will suffice to keep internal order, and setting up a system of inspection and control to see that the conquered do not exceed the strength assigned to them. Should the Germans win, they will probably exercise this control themselves; should the British win, the control would doubtless be in the name of a European federation or of some other international body; but in either case the principle would be the same. The oft-heard proposal for an international air force would fit well into such a scheme.

It seems at least possible, however, that resentment would develop and that the conquered would do what they could to arm themselves for a war of revenge. In that case, in so far as the system of inspection remained effective at all, the vanquished could hardly do other than prepare for guerrilla warfare fought with "bootleg" armament. They would smuggle in and manufacture the lighter weapons, planning to convert as many peace-time implements as possible into military weapons upon the outbreak of war—commercial planes into fighting planes, commercial tractors into tanks, etc.—and studying the strategy of irregular war.

Against this sort of thing the resource of the victor would be to play upon the world's desire for peace, emphasizing the truth that guerrilla warfare is a peculiarly ferocious and barbaric thing. Whatever might be the fortune of this debate, a successful monopoly of ordnance would, while it lasted, reduce the future of war to the future of irregular warfare.

The 40-mm. Antiaircraft Cannon

The Latest Automatic Weapon Now in Production

Maj. Daniel J. Martin*

THE funnel-mouthed Bofors 40-mm. "automatic field gun" has inspired international acceptance probably quite beyond any dreams of its designers—if cannon designers may be said to dream hopefully for popularity of a product. The gun already was in production by Bofors in Sweden when the Spanish War demonstrated the truth of a long-held military conclusion: That intermediate-caliber automatic cannon would be a requisite in future action for defense against low-flying aircraft.

Automatic antiaircraft cannon of various medium calibers also were under development at that time or were being manufactured in other countries, including the United States. Nevertheless, among the early 40-mm. Bofors gun purchasers were Great Britain, France, Poland, Belgium, Holland, Norway, and Sweden.

It was not long before an international controversy arose over what was the ideal caliber for automatic antiaircraft cannon for intermediate ranges. Partisans appeared for the 40-mm., 37-mm., 25-mm., and others. There are factors in favor of each.

PROOF FIRING THE NEW 40-MM. GUN

Great Britain has continued to be partial to the 40-mm. Bofors gun, and there have been many published reports attesting its efficiency and reliability. There have been stories that it was this gun in great numbers which enabled the British to make their successful withdrawal at Dunkerque. There are others which attribute the loss of Crete to absence of these weapons. Still others report that German fliers shy away from areas known to be protected by 40-mm. Bofors guns.

In 1940, the 40-mm. Bofors gun was the subject of exhaustive tests at Aberdeen Proving Ground, Md. Results of these tests, together with authoritative information on their European performance against low-flying aircraft, combined to effect standardization of a gun of this type by the Ordnance Committee early last spring as the "U. S. Army 40-mm. gun M1."

Contracts for manufacture of the gun have been awarded and the first pilot models were turned out in early summer. The Chrysler Corporation of Detroit has the prime contract for the gun and the Firestone Tire & Rubber Company of Akron, a prime contract for the carriage. Chrysler is subcontracting its work throughout its large organization, and Firestone has spread its work among 368 subcontractors.

The tactical need for protection of field forces and installations against low-flying aircraft had been visualized prior to the Spanish War, but it remained for operations there to indicate its exceptional importance. Almost from the first day of the current European conflict, this requirement has repeatedly reasserted itself.

It has been widely known for some time that aircraft most dangerous to field forces do not fly high. Moreover, bombardment of cities and industrial areas has been conducted for months at low and intermediate altitudes, as well as from greater heights. Higher aircraft speeds and aircraft armor also are considerations. The 40-mm. Bofors antiaircraft automatic cannon (termed by the manufacturers the "40-mm. automatic field gun") has proved itself under these conditions of aircraft attack. The object of its fire is to put aircraft out of action by direct hits. Its shells are detonated instantly on impact.

"Point-blank" fire is made possible by tracking aircraft with reflecting sights and adjusting the corrector with great accuracy. Use of tracer shell permits making necessary corrections and observation of the shell group near the target.

Fire is usually in bursts of four to five rounds, full automatic. The gunner may use further continuous automatic fire if his observations show it can be effective. High muzzle velocity, 2,850 feet a second, results in a virtually straight trajectory up to about 3,280 yards. Short firing time makes it possible to regulate the fire quickly. This is now necessary because the faster bombers remain within effective range for not more than ten seconds. The sooner the bursts reach the target, the more rapidly can any necessary corrections be made. The 40-mm. Bofors gun can be aimed with great rapidity before an attack made at extremely short range can accomplish all the intended results.

General data of the 40-mm. gun are as follows: Rate of fire, 120 to 140 rounds a minute; weight of gun in firing and traveling position, 4,300 pounds; maximum range, 11,000 yards, horizontal; weight of projectile, 2.205 pounds;

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weight of powder charge, 0.628-pound; weight of fixed cartridge, 4.63 pounds; muzzle velocity, 2,850 feet a second; vertex for time of flight of 11.5 seconds, high-explosive tracer shell, 5,391 yards; range for time of flight of 11.5 seconds, high-explosive shell, 5,413 yards; gas pressure, maximum, 42,630 pounds per square inch; elevation field, minus 5 degrees to plus 90 degrees; traversing field, 360 degrees; length of recoil, 7.874 inches; wheelbase, 125.98 inches; maximum vertical range for 11.5 seconds, 5,391 yards.

Following are the general characteristics of the gun: The barrel is provided with a counter-recoil spring and flash hider. The latter prevents the flash from blinding the crew, particularly during night firing. The barrel has no water jacket, and the counter-recoil spring consists of a cylindrical coil spring installed around the barrel. The front of the recoil spring bears against a nut screwed to the barrel and the rear of the spring bears on a washer housed in the front casing. The muzzle is conical and its exterior is provided with a screw thread for the flash hider. The bore consists of the chamber, the transition cone and sixteen rifling lands.

THE NEW ANTIAIRCRAFT GUN AND ITS MOBILE CARRIAGE

THE original Bofors rifling curve forms the arc of a circle and has an initial twist of one turn in forty-five calibers and a terminal twist of one turn in thirty calibers. The rifling has a uniform profile with a depth of 0.0236-inch and a width of 0.2205-inch; width of the lands is 0.0886-inch. The receiver is united to the barrel by a bayonet lock. A barrel may be changed in approximately two minutes. The bottom of the receiver is equipped with a lug to which the piston rod of the recoil mechanism is fastened. The rear is provided with two more lugs to which the loading tray is fastened.

The breech mechanism is of the vertical-wedge type and is locked automatically when a shell is inserted. It opens during the recoil when the case is ejected and consists mainly of the wedge, operating device, firing pin, cocking and releasing mechanism for the firing pin, ejector, and safety devices.

During recoil, the barrel moves backward in the recoil sleeve which is attached to the cover of the automatic mechanism. The recoil brake is installed beneath the recoil sleeve. The elevating cranks and arc are fastened to this cover.

The completely automatic vertical wedge mechanism is equipped with all necessary safety devices. The magazine holds two cartridge clips, each containing four rounds, and is filled by inserting the clips in the guide bars of the magazine. The loading rammers automatically drop to one side during loading. The loading mechanism is entirely automatic, permitting continuous fire, and the gun is loaded conveniently at all elevations. During fire, empty cartridge cases are guided by the chutes installed for the purpose.

The hydraulic recoil brake comprises the brake cylinder and packing box, piston and piston rod, and the regulating rod and valve. During recoil, the piston rod and piston are drawn backward, whereupon the liquid behind the piston is forced through a narrow canal in the piston into a chamber in front of it. The area through which the liquid flows is governed by the variation in the diameter of the regulating rod. Length of the recoil is determined by the resistance of the liquid to its passage through the canal and the counter-pressure of the counter-recoil spring. When recoil ceases, the barrel is again brought back into position by the action of the counter-recoil spring. The speed of counter-recoil, and consequently the rate of fire, can be regulated by adjusting a valve in the rear end of the regulating rod. The recoil sleeve incloses the breech and automatic mechanisms.

The automatic mechanism comprises both the parts by means of which the cartridges are fed in and the parts which bring the cartridges forward and insert them in the chamber. A feeding device feeds the cartridges one by one into the loading tray, while a rammer pushes forward the cartridge deposited on the loading tray and inserts it in the chamber. A hand-cocking device is used when the first cartridge is inserted in the automatic mechanism and also when the remaining cartridges are taken out.

The equilibrator consists of two equilibrating springs inclosed in cylinders. The equilibrator is installed beneath the elevating system.

The yoke of the mount is composed of two sides of the mount joined by means of a tubular crosspiece and fastened to the upper base plate. The upper base plate rests upon a double-action axial ball bearing and is centered about a pivot on the lower base plate by means of a radial ball bearing. The exterior of the lower base plate is provided with a flange which is fastened to the foundation by means of anchoring bolts. The yoke of the mount has a platform and three adjustable seats for the gun crew.

ELEVATION of the gun is effected by a double elevating crank on the left side. The motion of the crank is transmitted by means of a conical gear in the elevating housing and a screw gear on the elevating crank which engages the elevating arc. The gun is traversed from the right also by a double crank. The turning movement is transmitted by means of a gearing installed in the upper traversing housing and a shaft on the lower traversing housing provided with

two ball bearings. Thence, the movement is transmitted to the traversing shaft by means of a gear which engages the ring gear fastened to the lower base plate.

The gun can be fired either by the operator of the elevating mechanism or by the man adjusting the corrector, each of whom has a firing pedal. When one of the pedals is pressed down, the movement is transmitted by means of connecting rods and angle bars to the releasing arm of the automatic mechanism. The firing mechanism can be placed on safe or can be adjusted for single-shot or automatic fire by means of a lever.

The Bofors aiming and sighting apparatus is designed to compute the necessary firing data; namely, the vertical angle of lead (additional angle of height) plus the angle of elevation, and the lateral angle of lead (additional lateral angle), and to transmit them to the reflecting sights. The aiming and sighting apparatus consists of the corrector, the transmission apparatus—with a device for correction of the angle of height and the lateral angle—and the reflecting sights.

Using the Bofors sighting gear, the gun, in firing, is laid by the elevating- and traversing-gear operators, who track the aircraft by means of the reflecting sights. Each reflecting sight is equipped with electrically illuminated cross hairs which are reflected into the gunner's eyes through a transparent glass plate placed at an inclination of forty-five degrees. The reflecting sights are provided with dimmers, inserted by means of a single operation, and with a framed diopter, carried as a spare part.

The Bofors corrector is fitted to one side of the gun and is operated by one or two men. The initial data of the corrector are angle of course, speed of target, and range. The data which are automatically transmitted to the reflection sights are definitive firing data for azimuth and elevation. The corrector also can be set for diving targets. Sighting and laying gears are operated by three or four men. Data relating to the Bofors aiming and sighting apparatus are: graduations of range scale, zero to 5,468 yards; graduations of speed scale, zero to 492 feet a second; diving angles, minus 20 to plus 90 degrees; course scales, 360 degrees.

THE principal projectile used with the Bofors 40-mm. automatic gun is tracer shell with a supersensitive nose fuze. It consists of these main elements: bursting charge, tracer composition, nose fuze, and base fuze. When the round is fired, the tracer composition is ignited by the base fuze about fifty-five yards from the muzzle. The light from the burning tracer composition thus becomes visible from the gun emplacement and appears as a reddish star, showing the shell's trajectory.

During automatic fire, the light emitted by the tracers, following one another in rapid succession, resembles a light beam. When the shell hits the target, the bursting charge of tetryl is detonated by the nose fuze and the shell explodes. The nose fuze already has been armed at the time of firing and hence is fully armed as soon as it leaves the muzzle of the gun. The shell will burst even if it merely hits the fabric of an airplane wing, due to the split-second action of the nose fuze—about .00015-second. If the shell misses the target, it will explode automatically when the tracer composition burns out, since the composition ignites the percussion cap, thus setting off a detonating pellet.

The gun is mounted on a cross-bed carriage which allows a traversing field of 360 degrees. On changing from traveling to firing position, which is effected in about twenty-five seconds, two lateral outriggers are swung out and the cross-bed lowered to the ground by turning the axle trees. The lowering device is balanced by means of springs. On uneven ground, the cross-bed is leveled by means of four adjustable ground plates attached to the extremities of the four arms of the cross. The carriage also is fitted with four anchoring posts.

The four wheels are equipped with pneumatic tires. The front wheels have an angle of deviation of forty-two degrees to either side and the front axle a tilting liberty of plus or minus fifteen degrees. The rear wheels are fitted with hydraulic automobile brakes. Spring suspension is arranged according to the Bofors parallelogram system, permitting the wheels to spring independently of each other.

THE Bofors Company (Aktiebolaget Bofors) is as interesting as its guns. It manufactures no secret weapons of its own design but obtains patents in as many countries as possible and sells to any available market. Located at Bofors, Sweden, 143 miles west of Stockholm, the concern is owned by private Swedish capital and has been manufacturing arms since 1884. Dr. Alfred Nobel (of Peace Prize fame), inventor of nitroglycerin explosives, was president of the company for several years prior to his death in 1896. Following the World War, the Krupp Company, restricted in Germany, acquired large interests in Bofors. The two companies pooled designs, and a satisfactory working agreement continued until 1937 when the Swedish Parliament passed a law prohibiting such foreign ownership, and Krupp withdrew.

Bofors has had a wide range of products, military and nonmilitary, although its production is now entirely devoted to the Swedish defense forces. It has been principally concerned with manufacture of artillery from 20 mm. to 30 cms., armor plate up to 0.59-inch in thickness, projectiles up to 14.96 inches, small-arms ammunition, commercial explosives and nitrocellulose by-products. Willing to take small orders for special armament, Bofors obtained much business from smaller countries for which other large firms would not make special designs.

Bofors is almost entirely self-sufficient as to its sources of raw materials. Owning its own iron mines, forests, and connecting railroads, it produces its own hydroelectric power and charcoal. It is reported that Bofors believes its charcoal makes better steel than any coke or coal process because of the low sulphur and phosphorus content.

All Bofors plant construction since the World War has been planned with antiaircraft protection in mind. The company has set up its own antiaircraft defense system with its 40-mm. "automatic field cannon," and also is protected by army units. Many other Swedish industries have purchased their own antiaircraft guns and have volunteer crews to operate them.

Four or five years ago, Bofors sold Poland a license to manufacture its 40-mm. antiaircraft guns. After the conquest of Poland, Germany sold such of these guns as had been captured in Poland back to Sweden. Sweden had at that time given nearly one-half of its antiaircraft guns to Finland and was anxious to replace them.

EDITOR'S NOTE.—A paper on the technique of manufacturing the carriage for the 40-mm. Bofors gun was given by J. E. Trainer, vice-president, Firestone Tire & Rubber Company, at the Twenty-Second Annual Meeting of the Army Ordnance Association in Detroit on October 9th. It will be published in the next issue.

Armament Progress

Statistics of the Current Program

The following list includes ordnance production contracts of $40,000 and above placed with private industry from August 1 to October 1, 1941; it does not include orders placed with the arsenals. Previous orders in the rearmament program were listed in the seven preceding issues of this journal, starting with the September-October 1940 issue.

Artillery Matériel and Components

Facility	*Amount*
Ahlberg Bearing Co., Chicago, Ill	$ 45,012.05
American Locomotive Co., Schenectady, N. Y	392,040.00
American Manganese Bronze Co., Philadelphia, Pa	52,700.00
Babcock & Wilcox Tube Co., Beaver Falls, Pa	93,027.14
Bethlehem Steel Co., Bethlehem, Pa	376,650.00
Colt's Patent Fire Arms Manufacturing Co., Hartford, Conn	685,672.65
Eclipse Aviation Division (Bendix Aviation Corporation), Bendix, N. J	275,538.10
Falls Rubber Co., Findlay, Ohio	103,814.64
Farquhar Co., A. B., York, Pa	553,111.65
Finkl & Sons Co., A., Chicago, Ill	131,825.00
Firestone Tire & Rubber Co., Boston, Mass	211,489.47
General Bronze Corporation, Long Island City, N. Y	65,872.00
General Steel Castings Corporation, Eddystone, Pa	2,975,091.10
Goodman Manufacturing Co., Chicago, Ill	85,968.00
Inland Steel Co., Chicago, Ill	542,314.50
International Nickel Co., New York, N. Y	81,105.30
Koppers Co., Baltimore, Md	226,836.00
Mackintosh-Hemphill Co., Pittsburgh, Pa	356,927.04
Midvale Co., Philadelphia, Pa	2,261,776.00
Ohio Steel Foundry Co., Lima, Ohio	698,625.00
Pittsburgh Steel Foundry Corporation, Glassport, Pa	463,028.00
Roth Co., Roy E., Rock Island, Ill	41,600.00
Sheet Aluminum Corporation, Jackson, Mich	131,598.20
Struthers-Wells-Titusville Corporation, Titusville, Pa	613,827.00
Waterbury Tool Division (Vickers, Inc.), Waterbury, Conn	310,000.00
Wood Manufacturing Co., John, Muskegon, Mich	124,204.70

Artillery Ammunition and Components

Aluminum Industries, Inc., Cincinnati, Ohio	$ 3,960,000.00
American Brass Co., Waterbury, Conn	52,621.69
American Can Co., New York, N. Y	7,087,755.17
American Forge Division (American Brake Shoe & Foundry Co.), Chicago, Ill	507,960.00
American Manufacturing Co. of Texas, Fort Worth, Tex	3,005,000.00
American Safety Razor Co., Brooklyn, N. Y	400,925.00
American Steel & Wire Co. of New Jersey, Philadelphia, Pa	225,164.81
American Thermometer Co., St. Louis, Mo	980,000.00
Armstrong Cork Co., Lancaster, Pa	3,582,000.00
Auto Specialties Manufacturing Co., St. Joseph, Mich	85,000.00
Axelson Manufacturing Co., St. Louis, Mo	754,900.00
Bauer Brothers Co., Springfield, Ohio	1,930,500.00
Beaird Corporation, J. B., Shreveport, La	2,354,000.00
Benrus Watch Co., Waterbury, Conn	210,687.50
Bethlehem Steel Co., Bethlehem, Pa	92,950.00
Bishop & Babcock Manufacturing Co., Cleveland, Ohio	2,096,766.00
Bliss & Laughlin, Inc., Buffalo, N. Y	67,764.90
Bristol Brass Corporation, Bristol, Conn	55,154.41
Budd Induction Heating, Inc., Detroit, Mich	160,500.00
Bulova Watch Co., Woodside, N. Y	69,627.00
Carpenter Steel Co., Reading, Pa	67,050.00
Chase Brass & Copper Co., Waterbury, Conn	56,426.72
Chrysler Corporation, Detroit, Mich	312,000.00
Cincinnati Ball Crank Co., Cincinnati, Ohio	284,050.00
Clark Grave Vault Co., Columbus, Ohio	889,100.00
Cleveland Container Co., Cleveland, Ohio	232,807.89
Crucible Steel Co. of America, New York, N. Y	219,156.30
Dresser Manufacturing Co., Bradford, Pa	962,500.00
Dunlap Co., John, Carnegie, Pa	970,000.00
Eaglesfield Co., R. D., Indianapolis, Ind	104,000.00
Electric Household Utilities Co., Chicago, Ill	757,050.00
Federal Laboratories, Inc., Pittsburgh, Pa	62,000.00

Ordnance Production Contracts

Facility	*Amount*
Gabriel Co., Cleveland, Ohio	$ 610,000.00
General American Transportation Corporation, Chicago, Ill	239,000.00
General Railway Signal Co., Rochester, N. Y	4,417,500.00
Grant Oil Tool Co., Los Angeles, Calif	322,988.78
Guide Lamp Division (General Motors Corporation), Anderson, Ind	611,000.00
H. A. K. Products Corporation, Fort Lauderdale, Fla	760,000.00
Hamilton Watch Co., Lancaster, Pa	5,720,000.00
Harvey Metal Corporation, Chicago, Ill	57,050.00
Ingraham Co., E., Bristol, Conn	97,572.00
Jones & Laughlin Steel Corporation, Aliquippa, Pa	4,788,460.00
Kilby Steel Co., Anniston, Ala	6,127,200.00
Kingston Products Corporation, Kokomo, Ind	76,348.80
Landers, Frary & Clark, New Britain, Conn	860,000.00
Leach Co., Oshkosh, Wis	132,300.00
Link Belt Co., Indianapolis, Ind	4,999,850.00
McKinney Manufacturing Co., New York, N. Y	56,030.80
Middlesex Paper Tube Co. of New Jersey, Burlington, N. J	366,378.77
Minneapolis-Moline Power Implement Co., Minneapolis, Minn	2,335,755.00
Mullins Manufacturing Co., Salem, Ohio	697,493.40
Murray Co., Atlanta, Ga	162,000.00
Murray Manufacturing Corporation, Brooklyn, N. Y	1,792,000.00
National Enameling & Stamping Co., Granite City, Ill	1,294,650.00
Norris, Inc., W. C., Tulsa, Okla	574,024.00
Oliver Farm Equipment Co., Chicago, Ill	2,832,732.00
Parish Pressed Steel Co., Reading, Pa	409,912.10
Peco Manufacturing Co., Philadelphia, Pa	772,950.00
Pittsburgh Steel Co., Allenport, Pa	1,890,000.00
Portland Forge & Foundry Co., Portland, Ind	127,000.00
Pullman-Standard Car Manufacturing Co., Butler, Pa	915,000.00
Regina Corporation, Rahway, N. J	548,895.00
Republic Steel Corporation, Massillon, Ohio	229,367.09
Rheem Manufacturing Co., New Orleans, La	1,034,250.00
Robertshaw Thermostat Co., Youngwood, Pa	1,720,800.00
Scovill Manufacturing Co., Waterbury, Conn	825,000.00
Sefton Fiber Can Co., St. Louis, Mo	1,019,431.56
Servel, Inc., Evansville, Ind	797,297.44
Seth Thomas Clocks Division (General Time Instruments Corporation), Thomaston, Conn	149,610.00
Sheffield Steel Corporation, Kansas City, Mo	600,000.00
Spang-Chalfant Division (National Supply Co.), Ambridge, Pa	5,093,130.00
Standard Container Co., Bloomfield, N. J	2,012,650.10
Stockham Pipe Fittings Co., Birmingham, Ala	271,260.00
Taylor-Wharton Iron & Steel Co., Easton, Pa	826,000.00
Tennessee Coal Iron & Railroad Co., Birmingham, Ala	260,000.00
Thibodaux Boiler Works, Thibodaux, La	900,000.00
Thompson Products, Inc., Detroit, Mich	43,023.80
Timken Roller Bearing Co., Canton, Ohio	166,400.00
Townsend Lawn Mower Co., Samuel P., Bloomfield, N. J	359,000.00
Tube Turns, Inc., Louisville, Ky	1,970,000.00
United States Pipe & Foundry Co., Burlington, N. J	163,845.00
Wagner Electric Corporation, St. Louis, Mo	1,530,000.00
Waltham Watch Co., Waltham, Mass	48,000.00
Weatherhead Co., Cleveland, Ohio	130,800.00
Wheland Co., Chattanooga, Tenn	396,000.00
Wyckoff Drawn Steel Co., Pittsburgh, Pa	148,363.70
Yoder Co., Cleveland, Ohio	486,400.00
York Safe & Lock Co., York, Pa	1,064,000.00

Small-Arms Matériel and Components

Auto-Ordnance Corporation, Bridgeport, Conn	$ 767,112.00
Bay State Tool & Machine Co., Springfield, Mass	40,809.36
Carnegie-Illinois Steel Corporation, Boston, Mass	171,798.00
Carpenter Steel Co., Reading, Pa	136,569.11
Colt's Patent Fire Arms Manufacturing Co., Hartford, Conn	45,100.00
Crucible Steel Co. of America, New York, N. Y	60,444.89
Fischer Spring Co., Charles, Brooklyn, N. Y	211,399.14
General Motors Corporation, Detroit, Mich	27,009,376.50
Hadley Special Tool Co., Boston, Mass	562,009.80
Jackes-Evans Manufacturing Co., St. Louis, Mo	964,800.00
Jones & Laughlin Steel Corporation, Pittsburgh, Pa	56,690.97
Kelsey-Hayes Wheel Co., Detroit, Mich	2,952,798.96
Kincaid Co., New York, N. Y	61,351.10

Ordnance Production Contracts

Facility	*Amount*
McEvoy Co., Houston, Tex	$ 274,736.79
Mill Rose Co., Cleveland, Ohio	58,961.68
Republic Steel Corporation, Cleveland, Ohio	377,867.28
Smith, Bradner & Co., Chicago, Ill	79,904.00
Stevens & Co., J. P., New York, N. Y	180,705.00
Stevens Walden, Inc., Worcester, Mass	1,033,106.25
Texas Tanning & Manufacturing Co., Yoakum, Tex	71,500.00
Union Hardware Co., Torrington, Conn	78,411.35
Wallace Barnes Division (Associated Spring Corporation), Bristol, Conn	60,000.00
Wallingford Steel Co., Wallingford, Conn	63,142.17
Winchester Repeating Arms Division (Western Cartridge Co.), New Haven, Conn	130,587.56

Small-Arms Ammunition and Components

Aluminum Seal Co., New Kensington, Pa	$ 224,700.00
Barium Stainless Steel Corporation, Canton, Ohio	2,717,446.16
Bristol Brass Corporation, Bristol, Conn	206,300.00
Scovill Manufacturing Co., Waterbury, Conn	340,000.00
Stamford Rolling Mills, Springdale, Conn	174,000.00
Wallace & Sons Manufacturing Co., R., Wallingford, Conn	980,400.00
Western Cartridge Co., East Alton, Ill	150,937.50

Bombs, Pyrotechnics, and Components

American Car and Foundry Co., Berwick, Pa	$ 467,000.00
Atlas Ansonia Manufacturing Co., New Haven, Conn	455,500.00
Bethlehem Steel Co., Bethlehem, Pa	71,008.00
Budd Manufacturing Co., E. G., Philadelphia, Pa	765,860.00
Chevrolet Motors Division (General Motors Corporation), Detroit, Mich	160,472.08
Delco Products Division (General Motors Corporation), Dayton, Ohio	1,605,240.00
Federal Laboratories, Inc., Pittsburgh, Pa	427,500.00
General Metalware Co., Minneapolis, Minn	321,408.00
Gilbert Co., A. C., New Haven, Conn	448,125.00
International Flare-Signal Division (Kilgore Manufacturing Co.), Tipp City, Ohio	600,472.19
Kushman Motor Works, Lincoln, Nebr	219,000.00
Lite Manufacturing Co., New York, N. Y	167,000.00
Magna Manufacturing Co., New York, N. Y	48,400.00
National Tube Co., McKeesport, Pa	4,141,500.00
Noblitt-Sparks Industries, Inc., Greenwood, Ind	54,525.92
Oliver Farm Equipment Co., Springfield, Ohio	804,100.00
Parsons Co., Detroit, Mich	606,040.00
Pittsburgh Water Heater Corporation, Pittsburgh, Pa	497,798.00
Radiart Corporation, Cleveland, Ohio	1,610,350.00
Regina Corporation, Rahway, N. J	548,895.00
Saginaw Stamping & Tool Co., Saginaw, Mich	171,909.50
St. Louis Steel Products Co., St. Louis, Mo	94,464.00
Triumph Explosives, Inc., Elkton, Md	104,900.00
Waterbury Clock Co., Waterbury, Conn	2,557,500.00

Powder, Chemicals, and Explosives

Barium & Chemicals, Inc., Willoughby, Ohio	$ 60,230.00
Du Pont de Nemours & Co., E. I., Pompton Lakes, N. J	138,750.00
Du Pont de Nemours & Co., E. I., Wilmington, Del	3,496,293.12
Hercules Powder Co., Kenvil Lake Junction, N. J	56,500.00
Hercules Powder Co., Wilmington, Del	543,750.00
King Powder Co., Cincinnati, Ohio	46,000.00
Olin Corporation, East Alton, Ill	165,000.00
Trojan Powder Co., Allentown, Pa	112,500.00

Combat Vehicles, Automotive Equipment, and Accessories

American Car and Foundry Co., New York, N. Y	$ 342,147.47
Bendix Products Division (Bendix Aviation Corporation), South Bend, Ind	54,047.80
Breeze Corporations, Inc., Newark, N. J	475,255.00
Continental Motors Corporation, Muskegon, Mich	370,807.27

Ordnance Production Contracts

Facility	*Amount*
Ever-Tite Manufacturing Co., Davenport, Iowa	$ 82,376.25
Guiberson Diesel Engine Co., Chicago, Ill	11,599,281.21
International Harvester Co., Chicago, Ill	84,700.00
Rockford Drilling Machine Division (Borg-Warner Corporation), Rockford, Ill	159,579.15
Scintilla Magneto Division (Bendix Aviation Corporation), Sidney, N. Y	91,210.47
Titeflex Metal Hose Co., Newark, N. J	86,341.15
Wellman Co., S. K., Cleveland, Ohio	45,638.36

Fire Control

Dictaphone Corporation, Boston, Mass	$ 521,994.89
Fecker, J. W., Pittsburgh, Pa	225,600.00
International Industries, Inc., Ann Arbor, Mich	264,500.00
Shuron Optical Co., Geneva, N. Y	60,000.00
Tinsley Laboratories, Berkeley, Calif	79,500.00
Unertl Co., John, Pittsburgh, Pa	90,300.00

Tools and Machinery

Atlantic Elevator Co., Philadelphia, Pa	$ 52,000.00
Austin-Hastings Co., Cambridge, Mass	627,000.00
Babcock & Wilcox Co., New York, N. Y	121,887.96
Bay Products Corporation, Newton, Mass	219,002.41
Day Co., J. H., New York, N. Y	45,310.00
Federal Machinery Sales Co., Chicago, Ill	59,659.00
General Machine Co., Newark, N. J	80,390.00
Heidrich Tool & Die Corporation, Detroit, Mich	601,207.50
Heppenstall Co., Bridgeport, Conn	46,975.84
Hercules Powder Co., Wilmington, Del	69,000.00
Industrial Steel, Inc., Cambridge, Mass	46,975.84
Kearney & Trecker Corporation, Milwaukee, Wis	40,868.90
Krueger & Co., H. R., Detroit, Mich	40,350.00
Manistee Iron Works Co., Manistee, Mich	1,153,239.00
McKiernan-Terry Corporation, Dover, N. J	485,330.00
Mesta Machine Co., Pittsburgh, Pa	323,600.00
Monarch Machine Tool Co., Sidney, Ohio	70,298.27
Motor Tool Manufacturing Co., Detroit, Mich	46,869.40
Murray Co., Atlanta, Ga	458,502.00
National Machinery Co., Chicago, Ill	63,506.24
New Britain-Gridley Machine Division (New Britain Machine Co.), New Britain, Conn	4,467,315.00
Niles Tool Works Division (General Machinery Corporation), Hamilton, Ohio	442,569.71
Pratt & Whitney Division (Niles-Bement-Pond Co.), West Hartford, Conn	53,034.00
Prentiss & Co., Henry, Boston, Mass	234,220.00
Prentiss & Co., Henry, New York, N. Y	62,000.00
Schollhorn Co., William, New Haven, Conn	61,819.80
Sowers Manufacturing Co., Buffalo, N. Y	98,550.00
Spayd-Ohio Manufacturing Co., Detroit, Mich	950,812.50
Star Tool & Die Co., Detroit, Mich	1,161,500.00
Stearns-Roger Manufacturing Co., Denver, Colo	830,400.00
Stedfast & Roulston, Inc., Boston, Mass	3,060,016.00
Surface Combustion Corporation, Toledo, Ohio	42,308.00
United Shoe Machinery Corporation, Boston, Mass	50,000.00
United States Hoffman Machinery Corporation, New York, N. Y	129,580.00
Veit & Young, Philadelphia, Pa	41,865.00
Verduin Machine Corporation, John, Paterson, N. J	136,800.00
Watson-Stillman Co., Roselle, N. J	129,500.00
Wilson-Brown, Inc., New York, N. Y	64,791.00

Gages

Hadley Special Tool Co., Boston, Mass	$ 129,490.36
Pratt & Whitney Division (Niles-Bement-Pond Co.), West Hartford, Conn	52,403.05
Sheffield Corporation, Dayton, Ohio	455,085.00

Facilities and Equipment

U. S. Rubber Co., Detroit, Mich	$ 60,440.00

Lubrication

The Essence of Ordnance Operation and Maintenance

Capt. George H. Schoenbaum*

ABOUT the time the fathers of this nation were planning the Declaration of Independence, one of their far-seeing members warned his contemporaries of how important the careful planning of each detail might become, by publishing these prophetic lines:

For want of a nail, the shoe was lost;
For want of the shoe, the horse was lost;
For want of the horse, the rider was lost;
For want of the rider, the battle was lost;
For want of the battle, the kingdom was lost;
And all for the want of a horseshoe nail!

The moral of Ben Franklin's ditty was well proved later, in the Revolution. The Ordnance Department believes these words of warning to have a significant bearing on the problem of preparing for the intelligent maintenance of the vast quantities of mechanized equipment now being built. Preventive maintenance, particularly as it relates to automotive and kindred types of equipment, has been a much-discussed subject in private industry for many years. Actually, however, it has been blessed with too few sincere advocates, and even fewer who have successfully put it into practice.

FIG. 1. ORDNANCE LUBRICATION TRUCK

One reason for the failure of preventive maintenance to be universally applied is that no fundamental preventive-maintenance program has been planned and inaugurated before the equipment it was intended to preserve had been placed in actual service. This line of reasoning thereby accounts for our concern today over the problems of introducing and putting into operation a complete preventive-maintenance program to provide for Ordnance matériel.

Of such a program, the lubrication phase is perhaps the most important, even though at first glance it might seem but a detail. It must be remembered that no machine can move without creating friction, and a little friction can wreck a lot of machinery. Thus, lubrication is the "Achilles heel" of a machine; or, if you please, the "horseshoe nail" of a modern mechanized army.

Perhaps a word or two on the magnitude of such a program will be helpful. Today, the various arms have in service many thousand tanks, trucks, half-track cars, tractors, and other units of equipment, each of which requires a detailed and accurate lubrication procedure if it is to operate successfully. Within a relatively short time, much additional equipment, requiring similar detailed servicing, will be issued.

The many benefits which result from the selection and application of correct lubricants are recognized by all large operators of motor vehicles. In the case of Ordnance equipment, the same benefits result but are of far greater significance. The use of unsatisfactory or inferior products, or the too-infrequent application of suitable products by a fleet operator, will result in a high ton-mile operating cost; Whereas, in the case of Ordnance, not only will a higher maintenance cost result, but the life of much-needed equipment will be seriously reduced and the equipment made inoperative at critical times. Some conception of the maintenance problems confronting mechanized units can be gained from a recent estimate that $1,000,000 would be required for the maintenance of an armored division for 300 hours of operation. Ordnance lubrication problems, in many respects, are common to those of commercial fleets but are much more difficult for a variety of reasons.

Any program to better lubrication practices for equipment operated by troops must take cognizance of conditions that will exist in time of emergency and during training maneuvers. For this reason, and for simplicity, the number of products selected for the lubrication of a vehicle must be kept far below the number usually employed by fleet operators. Lubrication will have to be accomplished under the most adverse conditions in and near the combat zone. Power-operated equipment will not always be available, and for this reason softer lubricants, which have less "staying ability," may have to be used because heavier products cannot always be applied by hand guns.

The need for a carefully planned program has been forcefully demonstrated by many considerations. The necessity for a substantial reduction in the number of different types of lubricants required for the proper lubrication of this equipment was made obvious when it was found that the instructions of the equipment manufacturers, if followed literally, require that each Army post and each field organization have available over twenty different grades of lubricating oil and thirty different grades of greases, in addition to many petroleum specialties and related products. The difficulties attendant to supplying such a wide variety of products are obvious; furthermore, the problem is aggravated by

*Chief, Fuel and Lubricants Unit, Field Service, Office of the Chief of Ordnance. Captain, Ordnance Department, U. S. Army.

ORDNANCE DEPT. STARTING SERIAL No.—131. Located on plate on instrument panel.

CAR, SCOUT, M3A1

TABLE OF CAPACITIES AND RECOMMENDATIONS

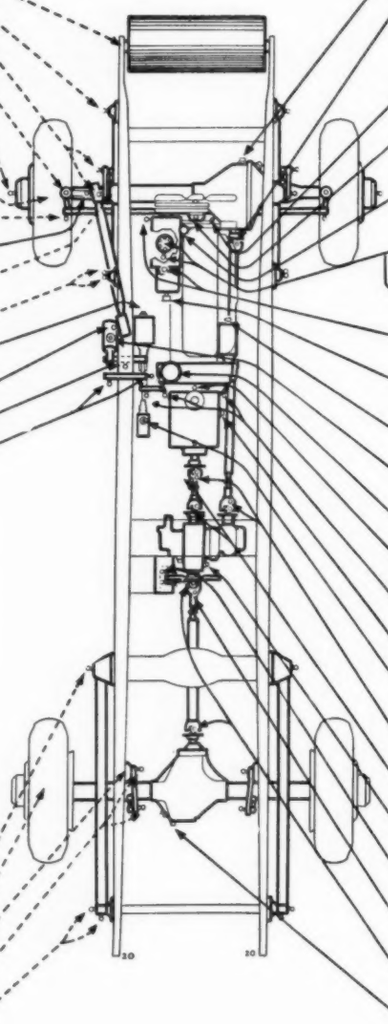
SNL G-67. Excerpt from TM 9-705

	Capacity	Above 90°	Lowest Expected Atmospheric Temperature				
			+32°	+10°	—10°	—30°	Below —30°
		SAE	SAE	SAE	SAE		
Crankcase	6 qt.	30	30	30	10	For operation in these temperature ranges, refer to OFSB 6-G-67 supplement.	
Transmission	5 qt.	140	140	90	80		
Differential (front)	4½ qt.						
Differential (rear)	3 qt.						
Transfer Case	3 qt.						

CAUTION Lubricate Dotted Arrow Points on BOTH SIDES

Lubricant ● Interval

- Bumper Roller (Note 13) EO 1
- Spring Bolt CG 1
- Shock Absorber Links (Some models) CG 1
- Steering Knuckle Upper Brg. CG 1
- Universal Joint (Rzeppa) and Steering Knuckle Lower Brg. (Note 8) CG 1
- Front Wheel Brgs. (remove) (Note 7) WB 5
- Tie Rod CG 1
- Drag Link CG 1
- Shock Absorber (Fill to plug level) SA 5
- Spring Shackle CG 1
- Brake Vacuum Cyl. (plug) (Sparingly) VO 5
- Drag Link CG 1
- Clutch Relay Shaft CG 1
- Pedal Shaft CG 1



Interval ● Lubricant

- 5 GO Front Axle Diff. (See Table) (Note 5)
- 1 GO Universal Joint (Note 9)

Serviced From Under Hood

- 1 CG Engine Trunnion Bearing
- 1 EO Fan (plug) (fill reservoir)
- 1 EO Crankcase (See Table) Drain, flush, refill. (Note 2) Check level daily
- 1 EO Distributor (sparingly) WB (late models, grease cup)
- 2 EO Wick under rotor (Note 10)
- 1 EO Generator (sparingly)
- ½ WP Water Pump Shaft (gr. cup) (Turn cup 1 full turn)
- 1 EO Starter (sparingly) (Note 12) (Reached from under car)
- 1 GO Steering Gear (plug)
- 5 *Oil Filter* (Note 11)

- ½ EO Clutch Release Bearing
- 1 CG Clutch Shaft
- 5 GO Transmission (See Table) (Note 5)
- 1 HB Brake Master Cylinder (Refill to ¾ in. below hole)
- 1 GO Univ. Slip Joint (Note 9)
- 1 GO Universal Joints (Note 9)
- 5 GO Transfer Case (See Table)
- 1 CG Propeller Shaft Brake
- 1 GO Univ. Slip Joint (Note 9)
- 1 GO Universal Joints (Note 9)
- 5 GO Rear Axle Diff. (See Table) (Note 5)

KEY

Lubricants	Intervals
EO—Engine Oil Crankcase grade	½—500 miles
GO—Gear Oil	1—1,000 miles
CG—Chassis Grease No. 0 (below 32° F.) No. 1 (above 32° F.)	2—2,000 miles
WB—Wheel Bearing Grease No. 2	5—5,000 miles
WP—Waterproof Grease No. 4	
PO—Penetrating Oil	Check Daily
SA—Shock Absorber Fluid (Note 6)	Crankcase and Air Cleaners
HB—Hydraulic Brake Fluid	
VO—Vacuum Cylinder Oil	

- Spring Bolt CG 1
- Rear Wheel Brgs. (remove) (Note 7) WB 5
- Shock Absorber (Fill to plug level) SA 5
- Shock Absorber Links (Some models) CG 1
- Spring Shackle CG 1

NOTES Additional Lubrication and Service Instructions on Individual Units and Parts NOTES

1. AIR CLEANERS—(Engine) Check level and refill oil cup to bead level daily with EO. Drain, clean and refill every 100 to 1,000 miles, depending on operating conditions. Every 2,000 miles, also remove air cleaner and wash all parts. (Brake Vacuum Cylinder) Every 3 months remove brake vacuum cylinder air cleaner, located under hood, clean hair and recil with EO.
2. CRANKCASE—Drain only when engine is hot. Flush with 4 qt. SAE 10, idle engine 5 minutes and drain. Refill to FULL mark on gage. CAUTION: Be sure pressure gage indicates oil is circulating. See Table.
3. INTERVALS indicated are for normal service. For extreme conditions of speed, heat, water, mud, snow, rough roads, dust, etc., change crankcase oil and lubricate more frequently.
4. FITTINGS—Clean before applying lubricant. Lubricate until new grease extrudes from the bearing. CAUTION: Always lubricate chassis lubrication points after washing vehicle.
5. GEAR CASES—Check level every 1,000 miles, add lubricant if necessary. Drain, flush and refill at end of first 1,000 miles; thereafter as indicated at points on guide.
6. SHOCK ABSORBERS — (Houde) Refill with Shock Absorber Fluid, Heavy. (Delco) Refill with Shock Absorber Fluid, Light.
7. WHEEL BEARINGS (Front and rear) — Remove wheel, clean and repack bearings.
8. RZEPPA UNIVERSAL JOINTS (Front wheels)—Remove level plug in rear of joint and fill through fitting in wheel hub to level of plug opening.
9. UNIVERSAL JOINTS AND SLIP JOINTS—Use same grades of GO as used for gear cases. Apply lubricant to joint until it overflows at relief valve, and to slip joint until lubricant extrudes.
10. DISTRIBUTOR—Wipe distributor breaker cam lightly with CG every 2,000 miles.
11. OIL FILTER—Renew filter element every 5,000 miles or oftener if necessary. After renewing element, refill crankcase to FULL mark on gage.
12. STARTER—Remove starter every 5,000 miles, clean, and lubricate Bendix drive sparingly with PO.
13. OIL CAN POINTS — Lubricate throttle and spark control rod ends, clevises, hinges, latches, bumper roller and pintle with EO every 1,000 miles.
14. POINTS REQUIRING NO LUBRICATION—Springs, Shock Absorber Links (some models, rubber).
15. POINTS TO BE LUBRICATED BY ORDNANCE MAINTENANCE PERSONNEL AT TIME OF GENERAL OVERHAUL—Clutch Pilot Bearing, Speedometer Cable.

CARRIER, MORTAR, 81 mm, HALF TRACK, M4

MFR'S STARTING SERIAL No.—M3-2.
Located on plate on instrument panel.

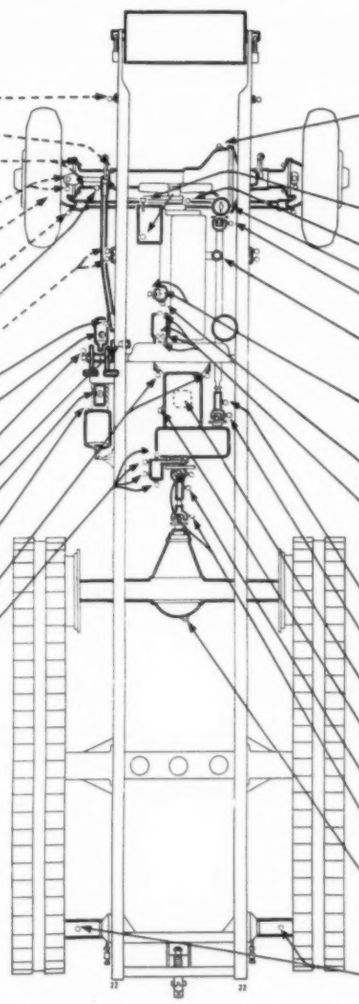
TABLE OF CAPACITIES AND RECOMMENDATIONS

SNL G-102 Excerpt from TM 9-710.

	Capacity	Above 90°	Lowest Expected Atmospheric Temperature				
			+32°	+10°	—10°	—30°	Below —30°
Crankcase	12 qt.	SAE 30	SAE 30	SAE 30	SAE 10	For operation in these temperature ranges, refer to OFSB 6-G-3.	
Trans. and Transfer Case	7½ qt.	140	140	90	80		
Differential (Front)	3½ qt.						
Differential (Rear)	6 qt.						

CAUTION Lubricate Dotted Arrow Points on BOTH SIDES

NOTE—See Reverse Side for lubrication of Track Suspension System



Lubricant ● Interval

- Spring Bolt CG 1
- Shock Absorber SA 5
- Universal Joint (Rzeppa) CG 1 (Note 7)
- Steering Knuckle, Upper and Lower CG 1
- Wheel Bearings (remove) WB 5 (Note 6)
- Tie Rod CG 1
- Drag Link CG 1
- Spring Shackle CG 1
- Drag Link CG 1
- Steering Gear GO 1 (Seasonal grade)
- Pedal Shaft CG 1
- Clutch Relay Shaft CG 1
- Brake Master Cylinder HB 1 (Refill to ¾" below hole)
- Brake Vacuum Cyl. (plug) VO 5 (sparingly)
- Clutch Cross Shaft CG 1
- Disc Brake CG 1

Interval ● Lubricant

- 5 GO Front Axle Diff. (See Table) (Note 5)

Serviced From Under Hood

- 1 WB Generator (grease cups) (Refill cup, turn 1 full turn)
- 1 CG Front Engine Support
- 2 *Oil Filter* (Note 10)
- 1 GO Universal Joint (SAE 140) (Reached from under vehicle) (Note 8)
- 1 EO Crankcase (See Table) Drain, flush, refill. (Note 2) Check level daily
- 1 WB Distributor (grease cup) (Refill cup, turn 1 full turn)
- 2 EO Wick under rotor (Note 9)
- 1 WB Tachometer Drive (Refill cup, turn 1 full turn)
- 1 EO Starter (oilers) (sparingly) (Some models 2 oilers) (Note 11)
- CG Reduction Gear Case (plug) (Note 12)

- 1 GO Universal Slip Joint (SAE 140) (Note 8)
- 1 GO Universal Joint (SAE 140) (Note 8)
- 1 WB Clutch Release Brg. (fitting) (Remove bottom plate of clutch housing)
- 5 GO Trans. and Transfer Case (See Table) (Note 5)
- 1 GO Universal Slip Joint (SAE 140) (Note 8)
- 1 GO Universal Joint (SAE 140) (Note 8)
- 5 GO Rear Axle Diff. (See Table) (Note 5)
- 1 CG Idler Support Brgs.

KEY

Lubricants	Intervals
EO—Engine Oil Crankcase grade	1—1,000 miles
GO—Gear Oil	2—2,000 miles
CG—Chassis Grease No. 0 (below 32° F.) No. 1 (above 32° F.)	5—5,000 miles
WB—Wheel Bearing Grease No. 2	Check Daily — Crankcase and Air Cleaners
PO—Penetrating Oil	
SA—Shock Absorber Fluid, Heavy.	
HB—Hydraulic Brake Fluid	
VO—Vacuum Cylinder Oil	

NOTES Additional Lubrication and Service Instructions on Individual Units and Parts NOTES

1. AIR CLEANERS—(Engine) Check level and refill oil cup to bead level daily with EO. Drain, clean and refill every 100 to 1,000 miles, depending on operating conditions. Every 2,000 miles, also remove air cleaner and wash all parts. (Brake Vacuum Cylinder) Every 3 months remove brake vacuum cylinder air cleaner, located under hood, clean hair and recil with EO.
2. CRANKCASE—Drain only when engine is hot. Flush with 8 qt. SAE 10, idle engine 5 minutes and drain. Refill to FULL mark on gage. CAUTION: Be sure pressure gage indicates oil is circulating. See Table.
3. INTERVALS indicated are for normal service. For extreme conditions of speed, heat, water, mud, snow, rough roads, dust, etc., change crankcase oil and lubricate more frequently.
4. FITTINGS—Clean before applying lubricant. Lubricate until new grease extrudes from the bearing. CAUTION: Always lubricate chassis points after washing vehicle.
5. GEAR CASES—Check level every 1,000 miles, add lubricant if necessary. Drain, flush and refill at end of first 1,000 miles; thereafter as indicated on guide. Check with vehicle on level ground.
6. FRONT WHEEL BEARINGS—Remove wheel, clean and repack bearings, also remove, clean and lubricate spindle bushing with WB.
7. RZEPPA UNIVERSAL JOINTS (Front wheels)—Remove level plugs, fill through rear plug hole until lubricant is level with opposite hole. Every 5,000 miles remove, clean and inspect universal joints. Reassemble, remove plug in spindle, insert fitting and inject 1 lb. CG. Replace plug. Refill universal joint housing.
8. UNIVERSAL JOINTS AND SLIP JOINTS—Apply lubricant to joint until it overflows at relief valve and to slip joint until lubricant extrudes from vent at universal joint end of spline.
9. DISTRIBUTOR—Wipe distributor breaker cam lightly with CG and lubricate breaker arm pivot with EO sparingly every 2,000 miles.
10. OIL FILTER—Renew filter element every 2,000 miles of oftener if necessary. After renewing element, refill crankcase to FULL mark on gage.
11. STARTER—Remove starter every 5,000 miles, clean, and lubricate Bendix drive sparingly with PO. Lubricate Bendix drive shaft outer bearing through oiler with EO.
12. STARTER REDUCTION GEAR CASE—Every 6 months remove plug in top of housing and refill with CG.
13. OIL CAN POINTS—Lubricate throttle ends, clevises, hinges, latches, vacuum cylinder valve and power lever linkage, bumper roller slides and bushings and pintle with EO every 1,000 miles.
14. POINTS REQUIRING NO LUBRICATION—Springs, Shock Absorber Links, Bumper Roller Brgs., Water Pump and Fan.
15. POINTS TO BE LUBRICATED BY ORDNANCE MAINTENANCE PERSONNEL AT TIME OF GENERAL OVERHAUL—Clutch Pilot Bearing, Speedometer Cable (See OFSB 6-G-102).

the fact that the more numerous the grades and types of lubricants are permitted to be, the more numerous are the chances of either the wrong lubricants being applied, or of no lubricants being available for application.

The supply position of the petroleum industry in various areas, the difference in the products offered for the same type of service by different companies, and the actual question of which product is best for military use must be taken into consideration in the planning of a truly comprehensive lubrication program.

THE lubrication program developed by the Ordnance Department has been divided into four important phases: (1) the phase dealing with the products; (2) the phase dealing with lubrication instructions essential to insure proper use of these products; (3) that of providing the proper equipment for the application of these products and the interrelationship of design and lubrication; (4) a follow-up plan consisting of the selection and training of personnel for supervisory field work, together with the inauguration of a system of follow-up by the use of records covering the "case history" of each unit. In the event of failure, this information will be used to determine the possible cause of the difficulty. Finally, films and other instructional material are prepared for use by arm and service schools and training centers.

Lubricant	Season
Engine Oil S.A.E. 10	Winter (Automotive)
Engine Oil S.A.E. 30	Summer (Automotive)
Engine Oil S.A.E. 50	Summer and Winter (Radial, Tank)
Diesel Engine Oil S.A.E. 10	Winter
Diesel Engine Oil S.A.E. 30	Summer
Gear Oil S.A.E. 80	Winter
Gear Oil S.A.E. 90	Summer
Gear Oil S.A.E. 140	Summer
E.P. Gear Oil S.A.E. 80 EP	Winter
E.P. Gear Oil S.A.E. 90 EP	Summer
Chassis Grease No. 0	Winter
Chassis Grease No. 1	Summer
Wheel Bearing Grease No. 2	Summer and Winter
Waterproof Grease, No. 4	Summer and Winter
Hydraulic Brake Fluid	Summer and Winter
Shock Absorber Fluid, Light	
Shock Absorber Fluid, Heavy	
Vacuum Cylinder Oil	

Table 1. U. S. Army Standard Nomenclature for Automotive Lubricants and Specialties

To understand the many and varied problems affecting the selection, simplification, designation, and standardization of products, it will be necessary first to review briefly the policies and practices in effect prior to the present emergency with respect to product recommendations and the interrelationship of the Ordnance Department, the Quartermaster Corps, and the various arms operating equipment issued by these services. In the past, the Ordnance Department, as a matter of policy, has attempted to adhere strictly to the recommendations of the manufacturers of equipment whether they be commercial concerns or Ordnance arsenals. In the case of commercial manufacturers, this was done in order not to invalidate warranties and, in both cases, because it was believed that the manufacturers "knew best" what their equipment required. Factual information has proved the latter not always to be the case. The variety of special and proprietary brands prescribed by the many manufacturers obviated the possibility of adhering to this policy from a supply standpoint.

It is the responsibility of the Ordnance Department to prescribe lubricants and lubrication practices for all ordnance matériel. However, only a very small per cent of the total volume of lubricants used for ordnance matériel is procured and issued by the Ordnance Department. All engine and chassis lubricants, whether for ultimate use in Ordnance or Quartermaster equipment, is issued by the latter. The need for the closest coöperation and coördination between these two services is very apparent. The appointment of a War Department Committee on Liquid Fuels and Lubricants, at the instigation of the Ordnance Department, has provided a means for the simplification and standardization of lubricants as well as fuels. Already a standard diesel fuel and a standard gasoline have been adopted and U. S. Army specifications written in order to permit the Army to retain the quality control of these products. One of the first actions of the War Department Committee on Liquid Fuels and Lubricants was to create a common language by standardizing an Army nomenclature for lubricants and related products which is likely to be adopted and designated by specifications. This is shown in Table 1.

It should be understood that the adoption of this nomenclature in no way precludes a further reduction in the number of products which will be made standard items of issue. It also should be understood that this list does not include items of Ordnance issue which are required solely for ordnance matériel. Instrument lubricants, recoil oils and similar products, which fall within the latter classification, are not considered within the scope of the War Department Committee on Liquid Fuels and Lubricants. They are discussed in subsequent paragraphs.

Those services designing equipment have been instructed by the Under Secretary of War to take cognizance of the standardization of fuels for Army vehicles. It is expected that those vehicles now requiring special fuels will soon be modified to permit the satisfactory operation of all vehicles in the armed forces on a single diesel fuel and a single gasoline. All lubricants generally required for the equipment issued by two or more services are rapidly being simplified, designated by U. S. Army specifications, and made "standard" by War Department regulations. Thus, a complete change in policy is being effected. In the future, all Army equipment, made to military characteristics and specifications, must perform satisfactorily on fuels and lubricants standardized by the War Department Committee on Liquid Fuels and Lubricants.

QUALITY has been given first consideration in the selection of all products, but availability necessarily has been given careful consideration also. In selecting products for particular items of equipment, the manufacturers' recommendations are studied carefully. When available, known performances in service—Army service—are weighed. After the type and consistency of the required products have been decided, all U. S. Government contracts are searched to determine if such products can be obtained under already existing contracts. A large percentage of all required oils can be obtained on the Navy Department's Annual Lubricating Oil Contract, and most of the required greases are

listed in the General Schedule of Supplies, Class 14, issued by the Procurement Division of the Treasury Department.

When a required product is not provided by any existing Government contract, a search is made to determine if a satisfactory specification exists. The preparation of specifications is a lengthy and difficult procedure and is resorted to only after every effort has been made on the part of the various agencies concerned to utilize one already in existence.

When it has been definitely established that one or more commercial brands are vastly superior to the average products sold for certain purposes, "acceptable" brand lists are established, pending the preparation of satisfactory specifications. It has been found expedient to require prior product approval for many items before permitting concerns to bid, a practice long utilized by the Navy Department with excellent results.

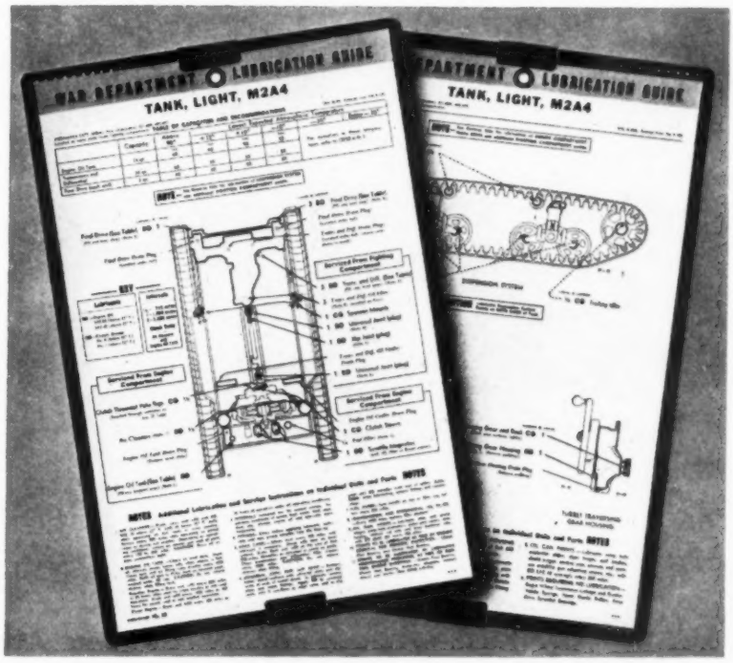


FIG. 2. LUBRICATION GUIDE (FRONT AND REVERSE SIDE) FOR THE LIGHT TANK

The progress made in simplification and standardization can best be illustrated by the status of recoil oils today as contrasted with their status at the outset of the emergency. One year ago, the Ordnance Department was procuring, storing, and issuing eight different grades of recoil oil, covered by six separate specifications. Although it was originally intended that several of these specifications would be superseded or replaced, their use was still required in technical manuals and other regulations which had not kept pace with the change in products. An analysis of the various specifications revealed that two products, a light and a heavy recoil oil, would prove sufficient and that, by making improvements in the specifications, satisfactory operation over a wider temperature range would be provided. The approach and solution to this problem are illustrated by Table 2, p. 398.

Those who have had experience in dealing with the standardization of lubricants and related products for the maintenance of a large variety of types and makes of mechanical equipment will appreciate the difficulties which are being surmounted. The number of different groups involved and their varied experience and training retards the speed of this work but assures a high degree of accuracy. All these endeavors have been closely coördinated with the petroleum industry and the related equipment manufacturers. The degree of coöperation between both groups has contributed much to the progress made.

The preparation and distribution of detailed lubrication instructions and guides for every unit of equipment requiring lubrication is second in importance only to providing proper lubricants. To prevent permanent damage due to improper lubrication and to reduce maintenance requirements, such instructions should be distributed prior to, or at the time of issuance of, the equipment for which they are intended. It will suffice to state that in the past not only have lubrication instructions failed to measure up to desired standards, but in many cases they were issued only after the equipment they covered had been in service many months. To remedy this, a carefully planned program has been placed in operation.

IT became apparent early in the planning of this program that the most expeditious method of obtaining results would be to contract for as much of the work as possible with organizations experienced in lubrication engineering which were already equipped with the man power and facilities to go into immediate production. With this in mind, a contract was negotiated with the Chek-Chart Corporation of Chicago, Ill., which has been engaged in this type of work for the past eleven years. This company prepares the lubrication information used by most of the major oil companies in their service stations today. In its civilian pursuits, the Chek-Chart Corporation has developed lubrication diagrams and procedures covering all types of passenger cars, trucks, tractors, and other types of mechanical equipment. It was believed that these would be readily adaptable to ordnance matériel. Although most of the men into whose hands Army maintenance will of necessity be placed have had no previous experience with such equipment, the Chek-Chart Corporation has prepared most of the training programs and material used by the petroleum industry for training similarly inexperienced personnel, so it is well qualified to handle this situation. The contract negotiated with the Chek-Chart Corporation covers three basic items:

1. This item will be a bound manual containing general lubrication instructions for all types of ordnance matériel and is designed to give the reader a broad fundamental lubrication knowledge. It measures 6 by 9 inches and will contain approximately 304 pages, together with about 400 illustrations. It is being written in a manner which should provide interesting reading and will be issued to all supervisory personnel as well as to all service schools and instructing personnel. This manual is divided into three important sections. The first treats the fundamentals of lubrication, covering a brief history of petroleum, the high lights of refining and blending, and the specifications and testing of oils. The second part will be devoted to a clarification and explanation of proper lubrication procedure for all ordnance

	Viscosity, Saybolt Universal Seconds								Viscosity Index	Viscosity, Keniematic				Pour Point	Gravity @ 60° F.		
										Centistokes			Centipoises, High Pressure	Degrees F.	Degrees A.P.I.	Specific Gravity	
Light Grades *New*	@ 100° F.		@ 70° F.		@ 30° F.		@ −40° F.			@ 100° F.	@ 30° F.	@ −40° F.	@ 100° F.				
	min.	*max.*	*min.*	*max.*	*min.*	*max.*	*min.*	*max.*	*min.*	*min.*	*max.*	*max.*	*min.*	*max.*	*min.*	*min.*	*max.*
Oil, recoil, U.S.A. 2-36D										4.0		110		−50			
Replaced U.S.A. 2-77	45	50	55	65										−45			
U.S.A. 2-36C (light)	45	75												− 5			
RIXS 42	43		55	75		145								0		0.835	0.870
RIXS 42 (Rev. 1)	43		55	70		170		500						−25			
RIXS 189	38	40												−45	39		
Heavy Grades *New*																	
Oil, recoil, U.S.A. 2-96A										82.0	1120		60	−20		0.860	0.885
Replaced U.S.A. 2-96	385	430				5000								−30			
RIXS 121B	380	400							115				35	−20			
RIXS 121 (Rev. 3)	380	400							115				60	−20			
U.S.A. 2-36 (heavy)	385	400												− 5			

Table 2. Recoil Oil Specifications

automotive and artillery matériel. The third and final part will discuss lubrication from the standpoint of variable operating conditions and the lubrication problems that may be encountered under actual field conditions. This manual will provide a complete general lubrication reference for the use of maintenance personnel and will be of great assistance to the various arm and service schools and instructors. The use of this manual by new military personnel during the course of their instruction will equip them with the fundamentals of lubrication which will insure a better knowledge of the lubrication maintenance of any ordnance matériel which they may have to use or service.

2. This item will be issued as a loose-leaf binder designed to contain detailed lubrication instructions (Ordnance Field Service bulletins, six series) for all major items of ordnance equipment. These bulletins will be reproduced as a part of the technical manual of the equipment concerned, and the loose-leaf feature of the binder will permit deletions and additions to be made from time to time. In addition to the bulletins, it will contain general lubrication instructions pertaining to ordnance artillery and automotive matériel. A section likewise will be devoted to a "product guide" which will list all lubricants to be used in ordnance automotive and artillery matériel, whether they are purchased by the Ordnance Department or the Quartermaster Corps. This binder is designed to make concise lubrication instructions for each piece of matériel, together with a complete list of the products to be used, readily accessible to personnel in the field.

3. This item consists of individualized War Department lubrication guides for ordnance automotive and artillery matériel. The guides embody suitable lubrication diagrams, completely identifying all points of lubrication, specifying lubricants to be used, and indicating lubrication intervals for each point. The guides measure approximately ten by fifteen inches and are mounted on heavy bristol board. The surfaces are coated with cellophane for protection against water, grease, and dirt, and each guide is edged with metal for further protection. Fig. 2 indicates the style of the guides. Each guide contains footnotes used to clarify information that space prohibits being given in the body of the guide. A table of capacities and recommendations lists the types of lubricants to be used in the engines and gear housings under various atmospheric temperatures. Lubrication guides for the scout car and the half-track mortar carrier are shown on pages 394 and 395 respectively.

In certain instances, where extra equipment requiring lubrication is carried on the vehicle, it has been deemed advisable to separate the vehicle chassis from its accessory equipment. For example, the guide for a tractor equipped with a winch is shown with a tractor diagram on one side and the winch on the reverse side. A gun carriage will be shown on one side and the gun on the reverse side. In this way, each guide is complete for the unit for which it was designed, while at the same time the information contained is not crowded to a point where the guide becomes difficult to interpret or read.

War Department lubrication guides are being made a part of the accessory equipment for the matériel they cover, and it is believed that personnel, with little or no lubrication experience or mechanical background, can be readily trained to care for the equipment assigned to them. The Ordnance Department lubrication program, embracing the above-mentioned items, will enable those charged with the maintenance of ordnance matériel to expedite the training of men, to insure a standard of lubrication throughout the armed forces, and to provide complete protection of equipment. This new lubrication program will supersede all previous lubrication data issued to the field. Compliance with the lubrication instructions issued under the program will be mandatory upon the using arms.

No discussion of the Ordnance lubrication program would be complete without mentioning the importance of giving careful consideration to lubrication during the design and standardization of equipment. Careful investigation has repeatedly shown that many so-called lubrication problems

have resulted from faulty design or the absence of satisfactory provisions for lubrication. Slight mechanical modifications already have solved many such problems. By incorporating satisfactory seals in the traversing and elevating gear housings on artillery matériel, the lubrication of these parts can, in the greater number of instances, be accomplished with oils, whereas in the past, cup greases have been used almost entirely.

Although it may be expedient to attempt to remedy some of the present difficulties by the use of "special lubricants," their final elimination will only result from improved design. Many benefits will result from the decision to standardize grease fittings on all vehicles procured and manufactured by the Ordnance Department. Many items now have as many as three different types of grease fittings, which is an obvious detriment, not only because of the many adapters required, but also because it makes the lubrication of such equipment more difficult and less likely to be accomplished satisfactorily.

For the past several months, the Ordnance Department has been studying the design of mobile lubrication units which would be capable of rapidly lubricating a number of tanks or similar ordnance equipment. The primary function of the Ordnance Department, in this respect, is to advise the using arms as to the best method for lubricating the automotive matériel. In view of this, mobile lubrication units, issued to the using arms, will not be Ordnance vehicles. The basic requirements for such units are: first, it must be capable of simultaneously lubricating two vehicles at a time with all necessary lubricants; secondly, the vehicle must be capable of following a combat-vehicle column. One such unit (Fig. 1), manufactured by the Alemite Corporation to Ordnance requirements and specifications, has been assigned to the 30th Ordnance Company at Fort George G. Meade, Md., and this unit is now being given field trials at Fort Knox, Ky. To illustrate the speed with which vehicles may be serviced by such a unit, on a recent test with the Alemite truck it was possible to completely lubricate 4 light tanks in 18 minutes, whereas the normal time required to lubricate the same tanks was about 1½ hours. Completion of final designs is rapidly being accomplished, and mobile lubrication units will become a part of the Army's mechanized equipment in the near future.

IT IS obvious that any lubrication plan must be systematically followed up to insure its proper functioning. However, since the accomplishment of lubrication is, in all cases, either a function of the first or second echelon, no definite instructions concerning follow-up procedure can be prescribed by the Ordnance Department. It is expected that several important steps will be taken which will do much to call to the attention of the line organizations the importance of lubrication and the necessity for maintaining lubrication records.

Official approval recently has been secured for the assignment of qualified fuel and lubrication engineers to major Ordnance maintenance organizations in the field. Several lubrication follow-up systems have been devised at the instigation of the Ordnance Department and will be presented to the line organizations for their consideration. Enlargements of individual lubrication guides, suitable for instructional purposes, will be prepared and distributed to arm and service schools and training centers.

An educational program will be developed and instituted for the purpose of teaching proper methods of applying lubricants, and to advise operating personnel generally concerning the importance of fuels and lubricants in preventive maintenance. Government and industry have successfully used motion pictures for similar educational enterprises and consideration is being given to the adoption of this method.

In conclusion, it is well to point out that the success of our armed forces may very well depend upon good, sound, preventive maintenance. While lubrication, to the casual thinking person, may appear as a trivial detail, one must never forget that "the best laid plans o' mice and men gang aft agley" because someone neglected to take into consideration the extent to which some small oversight would affect the success of the "over-all" plans. Let not the mechanized forces which we now struggle to build and keep ready for action fail because someone forgot to keep intact the film of oil upon which a mechanized army must travel.

To those responsible for the inauguration and successful operation of the Ordnance lubrication program, it seems as though Benjamin Franklin's famous poem can well be paraphrased as follows:

For want of some oil, a bearing was lost;
For want of a bearing, an engine was lost;
For want of an engine, a tank was lost;
For want of a tank, a battle was lost;
For want of a battle, a democracy was lost;
And all for the want of a film of oil!

With apologies to its honorable author, we suggest this as a motto for those responsible for the lubrication of our modern mechanized equipment.

EDITOR'S NOTE.—In a move to simplify the problem of supplying oil and gasoline to Army vehicles in the field, vastly complicated by the demands of motorized warfare, the War Department has announced that one standard type of gasoline will replace the four varieties formely in use. This announcement embodies the findings of the War Department Committee on Liquid Fuels and Lubricants, which has made a study of the problem during the past several months.

The Army's standard gasoline is a high-test, 80-octane fuel like high-test commercial gasolines. Due to the better mileage it gives, as compared to lower-test fuels, it is expected that the Government's present drive for gasoline economy will be furthered by its adoption.

Fuels for diesel-powered vehicles will now be of three varieties instead of the former four, and lubricating oil for diesel vehicles has been similarly standardized.

Airplanes and medium tanks which use airplane engines will continue to use aviation gasoline which meets Army-Navy Aëronautical Board specifications.

While no mechanical changes will be necessary in motor vehicles now in use, it is anticipated that the use of one standard gasoline may influence the design of future models.

Administrative vehicles—those in use at Army posts, camps, and stations—are exempted from this standardization move, but its advantages in storing and distributing oil and gas in the field are obvious.

(In response to a number of requests, this article will be reprinted in brochure form, and will be available to readers of ARMY ORDNANCE without charge upon request to the Editorial Offices, 705 Mills Building, Washington, D. C.)

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NOVEMBER-DECEMBER, 1941

Month by Month

THE RIGHT OF THE WELL-DISPOSED AMERICAN citizen to keep and bear arms—a right guaranteed him by the Constitution of the United States—was reasserted recently by the Military Affairs Committee of the House of Representatives. This action came at a time when reassurance was needed. The most dangerous effect of the present national-defense program, requiring hundreds of Government-owned plants for the production of armament, will be the monopolistic use of those plants by the Government in peace time. In the hands of un-American leaders, the plants could be used to disarm our citizens. That is to say, there would be no private arms production—and out would go another constitutional guarantee.

It must be insisted that no disposition be made of these plants which would in any way infringe the right of the private individual to keep and bear arms. If these plants are operated by the Government—as many factions are urging even at this time—then the death knell will be sounded for a private arms industry, and the individual American citizen will not have the wherewith to guarantee his constitutional right. A despotic government might disarm every American citizen by a single fiat!

Anyway, the reassuring stand of the Military Affairs Committee was taken when the Draft Property Act (Senate No. 1579) was before the committee. The committee promptly amended the sweeping powers of the bill as follows: *"And provided further,* That nothing herein contained shall be construed to authorize the requisition or require the registration of firearms possessed by any individual for his personal protection or support (and the possession of which is not prohibited nor the registration thereof not required); nor shall this act in any manner impair or infringe the right of any individual to keep and bear arms."

The committee went even further in its enunciation of sound American doctrine. In its report on the House bill, the committee had this to say:

"The amendment provides in substance that nothing contained in the bill shall be construed to authorize the President to requisition or require the registration of firearms possessed by an individual for his personal protection or sport (the possession of which is not already prohibited nor the registration thereof required) and that the act shall not impair or infringe the right of an individual to keep and bear arms. . . . There appears to be no occasion for the requisition of firearms owned and maintained by the people for sport and recreation, nor is there any desire or intention on the part of the Congress or the President to impair or infringe the right of the people under Section 2 of the Constitution of the United States, which reads, in part, as follows: 'The right of the people to keep and bear arms shall not be infringed.' However, in view of the fact that certain totalitarian and dictatorial nations are now engaged in the willful and wholesale destruction of personal rights and liberties, your committee deem it appropriate for the Congress to expressly state that the proposed legislation shall not be construed to impair or infringe the constitutional right of the people to bear arms. In so doing it will be manifest that, although the Congress deems it expedient to grant certain extraordinary powers to the Executive in furtherance of the common defense during critical times, there is no disposition on the part of this Government to depart from the concepts and principles of personal rights and liberties expressed in our Constitution."

Here was a bill which was very slipshod, or else deliberately bad, in its original preparation. It was designed primarily to give the War Department power to requisition machinery in the hands of profiteers who were demanding unconscionable prices—meanwhile the national-defense program suffered. But the energetic authors of the bill quite overstepped the bounds of sensible American legislation. They proposed powers so sweeping that a basic constitutional right—the right to keep and bear arms—could have been infringed. Thank God that occasionally there are fearless legislators who will not permit the disarming of their own citizens while preaching armament for the citizens of other countries.

THE CONCERTED EFFORT OF THE WAR DEpartment, through its Contract Distribution Division, and the Office of Production Management, through a similar organization, to spread defense contracts over the entire country is showing wide effect. The Ordnance Department reported in mid-September that fifty of its prime contracts, totaling $271,651,962.06, were subcontracted to the amount of $163,538,719.92—or 60.2 per cent. A total of 9,974 subcontractors received work.

The highest percentage of subcontracting took place in those companies working on tanks and combat vehicles. A total of $98,519,010.30 out of $151,677,397.89 in prime contracts was farmed out. This amounts to 65 per cent. Artillery

contracts covered by the survey show 54.3 per cent in subcontracts; small arms, 56.6 per cent; ammunition, 54.5 per cent, and Defense Aid, 50 per cent. The prime contractor showing the largest percentage of subcontracts is the Dutton-Rainson Company for practice shells. Out of a contract amounting to $206,323, a total of $169,539, or 82.5 per cent, was subcontracted. In some cases, the subcontracts were for raw materials or finished parts which, under the War Department's and OPM's new restricted definition of subcontractor, would not now be considered subcontracts but were so considered when the contracts were let.

The organization of the War Department's new Contract Distribution Division was completed rapidly and already has made good progress in its work of spreading defense business to the small manufacturer whose normal peace-time work has been badly disrupted by the force of priorities. The new division works closely with similar organizations in the Navy and the Office of Production Management.

THE 125TH ANNIVERSARY OF THE WATERTOWN Arsenal, Watertown, Mass., is more than a mere recording of years in the development and production of military armament for the Army and Navy of the United States. The anniversary comes in a period of national emergency when the importance of this and other arms-manufacturing establishments takes on new significance. Brig. Gen. R. W. Case, commanding general at Watertown, in the leading article in this issue, recounts the work of the arsenal throughout a century and a quarter of service. Pioneer in gun making and constant advocate of metallurgical advancement, Watertown today is second to no other plant, private or public, anywhere in the land in its importance to the armament-production program. ARMY ORDNANCE extends its felicitations to one of the pillars of our defense structure. Watertown has earned for itself throughout the years a reputation of dependability, the like of which is not exceeded anywhere. May this time-tried institution long hold its place of leadership not only in the present difficult days but even in the more uncertain days that are ahead when popular interest in armament production will not be as great as it is now.

At the ceremonies observing the anniversary at Watertown on September 23rd, the keynote of the arsenal's importance and historical significance was sounded by Maj. Gen. C. T. Harris, Jr., chief of the Industrial Service, Ordnance Department. General Harris said:

"At Watertown Arsenal, at the five other manufacturing arsenals of the Ordnance Department, and in the plants of a loyal and an efficient private industry the country over, the wheels are turning night and day. They are turning in order that the voice of this country, heard among the nations of the world, will not have the hollow sound that goes with warning words spoken when there is no power to enforce them. The armed forces, labor, and management stand, and should stand, as one man to guarantee that this nation will not speak in vain. In these times, a nation unarmed is a helpless nation. It is with pride, therefore, that on this day we salute an institution which, for 125 years has operated to arm the men of America.

"Watertown Arsenal has distinguished neighbors along the Charles River. Harvard University and Massachusetts Institute of Technology have grown old with Watertown, and each of these three neighbors has, in its own way, made great and lasting contributions to our national life. Each has grown mellow with the years without losing that forward look—the characteristic American tradition of progress.

"Watertown Arsenal has served the nation both in times of war and in times of tranquil peace, perhaps more trying than those of war, when the American people have given little thought to arming the nation for defense. At all times, the men of Watertown have set an example of loyalty that has seldom been equaled anywhere. There is a reason for this—an understanding knowledge back of the patience and good will shown here during the years.

"Today it gives me genuine pleasure to sit on this platform with James F. Maguire, Michael T. Carney, and Oscar W. Brockhouse, civilian arsenal workers with whom I served here thirty-one years ago. The decades of service that they have given to their country should stand as an example to workers the nation over. Honest, faithful, and intelligent service and leadership given by these and other workers to Watertown and to other Ordnance Department arsenals will erect a lasting monument for them in the hearts of people of this country."

THE WAR DEPARTMENT, THROUGH THE OFfice of the Under Secretary of War, has directed all of its 815 purchasing agencies throughout the country to effect new policies and regulations designed to bring more of the nation's industries into the defense program. This step will tend to eliminate distress caused by loss of business to small industries through the exercise of priorities and the scarcity of raw materials. The new regulations result from studies and conferences with the former Defense Contract Service of OPM and the Navy Department and have been furnished to the supply arms and services by the Contract Distribution Division which was created August 23rd in the Office of the Under Secretary of War.

Through the new plans, the industrial load of the defense program will be spread to more manufacturers by liberalizing the procurement methods and by putting into effect regional bidding. Industries now can negotiate with the Army for defense contracts, either individually or in groups. Awards in certain cases can be made at prices up to a fifteen per cent increase over the lowest quotation received or the last price paid. Trial orders may be placed and performance bonds may be eliminated when necessary. Inspections on items will be made at the plant in order to facilitate payments to contractors.

In submitting bids on competitive work, the bidder will attach a filled-in questionnaire regarding his plans for subcontracting. The prospective contractor also will state whether he has adequate plant facilities and trained labor on hand and if not what methods he proposes using to overcome the inadequacies; whether he possesses sufficient working capital; and the extent to which he will need new machine tools and if these tools are immediately available to him.

Contracting officers are authorized to divide awards so that parts can go to several plants instead of to single low bidders. Nearly all manufacturers successful on Army contracts in the future will have obligated themselves to arrange subcontracting in their own region so that other industries in the vicinity suffering from lack of civilian contracts can take up a share of the defense load.

Morale

An Editorial

THE popular morale of the nation—as distinguished from the military—is its collective mental state affected by such factors as zeal, confidence, spirit, and hope. Our popular morale as regards the all-out effort for arms production is not as high as it should be. Yet, unless that morale is of the highest, the armament production job will fail. We had better diagnose the malady quickly and adopt a remedy at once. For as popular morale goes, so goes everything else—the fighting forces as well as the human machinery of arms production. What are the causes of this low morale, and what are the remedies? Every fair-minded patriotic person will demand that adequate remedies be applied, no matter what the cost.

In seeking the causes one has only to remember the shabby pacifism of the American people during the last two decades. We are now paying the price of that pacifism, and no amount of tall talk can undo the damage done by years of idiocy. And the guilt should not be spread thin.

The pacifism of the press did untold harm to the national defense of the United States by its hypercritical denunciations of things military—especially military training and planning. It was the press that fanned to fever heat the stupid crusade against armament manufacture and developed an attitude of mind on the part of the people wherein arms making became synonymous with warmongering.

The pacifism of the pulpit all too frequently spoke in derogation of military discipline and training. It helped to inculcate in youth an unrealistic view of the problems of war and peace. It was the pulpit that often misconstrued the cause and effect of war. It was the pulpit—of all places—that frequently branded as unchristian the discipline of the soldier, the dignity of hard work, the thrift of the wise.

The pacifism of the politician was exceptionally blatant during those years in its childish crusades against our national-defense machine. Some clumsy politicians did irreparable damage when they turned the technique of smear campaigning upon "munitions makers" and other exponents of military preparedness. Consummate hypocrites, other politicians all but starved the defense forces while wasting billions of dollars on make-believe hard times. It was the cheap politician who misled the people by broadcasting his own ignorance of the national defense at a time when his voice should have been raised in the soundest support of it.

The pacifism of the pedagogue was yet more serious. It went to such extreme lengths as to permit an alien visitor to our shores (now safely established in one of our larger universities), to urge the youth of America to renounce arms for the defense of country, thereby striving to indoctrinate our young men with the contemptible treachery of the Oxford Union and the Communist. It was the misguided pedagogue who germinated false doctrines concerning war and peace akin to his other false theories.

Do you question the fact of such indictments? Then take but one example—it is from the *Pilgrim Highroad,* "a magazine for young people," issued under certain religious auspices, May 1934, Vol. II, No. 9, p. 30. In a report in that publication on the Student Peace Poll on War, prepared by the Intercollegiate Secretary, Y.M.C.A., at New York University, the chairman, Committee on Student Enrollment, War Resisters' League, wrote: "Young people today are finding facts. They are thinking straight. They see that covenants and pacts and treaties alone are not enough to free us from the war plague which is in our veins. They are ready to offer their lives and their liberties for that purpose. It is magnificent. They are daring to carry their faith into action. As Einstein said, 'Our governments are in a rut. They either cannot or will not disarm and trust to justice.' *The students are helping to make a new day of peace possible by committing themselves to the simple formula that wars will cease when men refuse to fight.*" (Italics ours.)

Multiply such instances by thousands and insert names and places as can every casual observer with the memory of a 7-year-old. The catalogue becomes so vast that only the blind will fail to see the extent of the damage that was done to the moral fiber of our people. In these and like causes lie the reasons for our present failure to meet defense obligations more spontaneously.

ON this foundation have we reared the uncertainties of the present. These uncertainties are most harmful. The armament objectives constantly change and are heaped, one upon another, to staggering proportions that prevent orderly planning or consistent solution. Add to this, the constantly changing method of administration wherein trial and experiment take the place of definite, long-projected policies. The overhead defense machine of the United States has become so cumbersome with its myriad officials, so changeable in its form, and so academic in many of its mental processes, that it creaks under its own weight. Finally, the unchecked license of radical unionism has shaken the faith of the ordinary citizen to the point where work to be done becomes an unknown quantity subject entirely to the whim of a few individuals in whose power lies the exclusive permission whether a fellow citizen may earn a livelihood or not. In this conglomeration of conflicting un-American interests, unsound social theories, and uncertain economic plans, piled high upon the background already described, lie the causes of the condition of the popular morale.

What is the answer? There is only one—sound generalship. Not alone the generalship of the battlefield but the generalship in the factory, on the farm, in the home. We have such generalship in the fighting forces; we do not have enough of it among our civilian leaders. Too many of them are afraid of their shadows! Until leaders come forward in all the respective spheres of action to contest the false doctrines that undermine our national strength, the arms-production program, and indeed every program for the welfare of our country, will progress at only a snail's pace. Such generalship, as far as the national defense is concerned, requires a deep knowledge of the problem. Arms production is a difficult task even for American manufacturing ingenuity. It is a field that has no place for ignoramuses, theorists, or prima donnas. Fearless men in civil life, imbued with a sense of sound generalship, will be the salvation of our armament effort, for they alone can instill the zeal, confidence, spirit, and hope that *are* popular morale. "Free peoples can escape being mastered by others only by being able to master themselves."

L. A. C.

Association Affairs

THE TWENTY-SECOND ANNUAL MEETING

THE Twenty-Second Annual Meeting of the Army Ordnance Association was held in Detroit, Thursday, October 9, 1941. It was an epoch-making occasion. The attendance was the second largest in the history of the Association, the papers and discussions were of utmost timeliness, the demonstrations were of unusual significance. The meetings and conferences were at the Book-Cadillac Hotel, and the demonstrations were at the Detroit Tank Arsenal, the world's largest arsenal now engaged in the mass production of the American medium tank. Inasmuch as time did not permit publication, in this issue of ARMY ORDNANCE, of the various addresses which were delivered at the meeting, all will be published in the next issue.

The first session of the Twenty-Second Annual Meeting was known as the Ordnance Production Session—a technical and scientific discussion of armament manufacture by officials of companies now actively engaged in the mass production of ordnance. Col. William W. Coleman, of Milwaukee, vice-president of the Association, presided at this session. Greetings to the assembled guests were given by Alex Dow, chief of the Detroit Ordnance District. The following papers were presented at this session: "Manufacture of Light Tanks," by Charles J. Hardy, president, American Car and Foundry Company, New York; "Manufacture of Propellent Powder," by Lieut. Col. Henry N. Marsh, manager, Smokeless Powder Operations, Hercules Powder Company, Wilmington; "Manufacture of Gun Carriages," by J. E. Trainer, vice-president, Firestone Tire & Rubber Company, Akron; "Graphic Production Control in the Arms Program," by James D. Mooney, vice-president, General Motors Corporation, New York. Approximately 500 members and guests attended this session which was held in the Crystal Ball Room of the hotel.

The Industrial Mobilization Luncheon, the annual gathering for the discussion of progress in special fields of ordnance manufacture, was held at 12:30 P.M. in the Grand Ball Room. This luncheon was originally scheduled to be held in the Italian Garden, but the numbers in attendance were so great that it was transferred to the larger hall. Approximately 700 members and guests attended the luncheon, which was presided over by Col. Frederick H. Payne, of Greenfield, Mass., vice-president of the Army Ordnance Association. The address, "The Detroit Tank Arsenal," was by K. T. Keller, president, Chrysler Corporation.

Immediately following the luncheon, members and guests were taken by bus to the Detroit Tank Arsenal. There were some thirty bus loads for the 12-mile journey to the arsenal and return. Upon arrival at the arsenal the group was divided into parties of twenty-five and escorted through the huge establishment. Visitors were taken down the main aisleway, on either side of which the tremendous manufacturing operations in progress could be observed. Next, the visitors inspected the production lines where three rows of medium tanks could be seen advancing toward completion after the fashion of automotive quantity production. Guests were then taken to the extensive testing grounds immediately adjoining the arsenal where each vehicle is given its prescribed test run before it is turned over to Government inspectors. This was one of the most inspiring sights seen at any of the annual meetings in the entire history of the Association, for here was the materialization of principles the Association has stood for from the very beginning. The Chrysler Arsenal is concrete evidence of American peace-time industry producing the things of war—the very culmination of doctrines that had been upheld at annual meetings of the society at the Aberdeen Proving Ground since the termination of the World War in 1918—"Pledged to industrial preparedness for war as our nation's strongest guaranty of peace."

The evening program began at 6:30 in the Crystal Ball Room where a reception was held for the Army Ordnance Medalists. Col. Herbert W. Alden, recipient of the Frank A. Scott Gold Medal for Meritorious Ordnance Service, and Col. James L. Walsh, recipient of the William Crozier Gold Medal for Meritorious Ordnance Service were the guests of honor. Promptly at 7:15 the distinguished guests were seated at the speakers' table and the entire assembly arose for the playing of the National Anthem. Throughout dinner, the Ordnance song by Irving Berlin, "Arms for the Love of America," was the musical theme interspersing standard classical selections by the orchestra.

Brig. Gen. Benedict Crowell, of Cleveland, Ohio, president of the Army Ordnance Association, was the presiding officer at the dinner. He presented Colonel Coleman, who, in addition to being vice-president of the Association, is also chairman of the Association's 1941 Committee on Awards. Colonel Coleman presented the candidates to receive the medals. In citing Colonel Alden, Colonel Coleman said:

"The Army Ordnance Association acclaims this leader among automotive engineers for his service to the national defense. Of sound judgment, wide experience, and acknowledged engineering skill, Colonel Alden typifies the best traditions of the patriotic citizen in his allegiance to the national defense. His service to industry and the Army ever has been distinguished by the absence of self-interest and the desire to give of the best of his talents to the betterment of military equipment for the defense of his fellow citizens. The Association honors Colonel Alden with its medal bearing the name of Col. Frank A. Scott, whose contributions in the field of industrial preparedness for the welfare of his country have brought about conditions under which engineering for national defense at last is given its proper valuation and appreciation."

When Colonel Walsh was presented to receive the Crozier Medal, Colonel Coleman read the following citation:

"The Army Ordnance Association acclaims the founder and first editor of its journal, ARMY ORDNANCE, for his foresight, perseverance, and continued loyalty to it and its ideals through many years. Untiring in his efforts to advance the Ordnance cause, ever zealous in his willingness to help the matériel progress of the United States Army, it is particularly appropriate that Colonel Walsh be the first recipient of the Association's medal bearing the name of his former chief, General Crozier, himself a prime advocate and willing sponsor of the Army Ordnance Association since its foundation twenty-two years ago."

Both medalists were acclaimed by the more than 1,300 members and guests who were in attendance at the dinner.

The addresses of the evening were as follows: Alvan Macauley, president of the Automobile Manufacturers Association, spoke on "The Automotive Industry and the National Defense"; W. H. Harrison, director of the Production Division, Office of Production Management entitled his address "Needed—More Armament Production"; Maj. Gen. C. T. Harris, Jr., chief, Industrial Service, Ordnance Department, spoke on "Ordnance of Tomorrow—Today." General Harris spoke on behalf of Maj. Gen. C. M. Wesson, Chief of Ordnance of the Army, who was overseas on official business.

The theme of this annual meeting was different from that of any preceding gathering of the Association. In former years, it had been the custom for officers of the Army and others connected with the defense forces to present current accounts of the plans, policies, and hopes of industrial mobilization. Now, with the country geared for armament production, it was most fitting that industry itself speak its mind on the job in hand. For this reason, representatives of private industry and officials of companies now engaged on mass-manufacturing operations were the speakers, and the story they told was one of inspiration and encouragement. It was evident from the spirit predominating

every session of the meeting, that American industry and the Ordnance Department of the Army are united in one great endeavor to speed the quantity production of armaments of all kinds. The Twenty-Second Annual Meeting of the Army Ordnance Association was successful in every respect but particularly in demonstrating that the things the Association has stood for consistently and steadfastly from the beginning are now in the stage of materialization. To have stood by one's guns has its satisfactions!

The Ordnance Endowment

OPPOSITE this page is inserted a copy of a brochure on the Ordnance Endowment. It is an invitation to the companies now engaged in ordnance production to be among the contributors to an endowment fund sponsored by the Army Ordnance Association. The brochure is published here in order that all readers of this journal may be familiar with the undertaking, the reasons which prompt it, the methods which are being followed, and the ultimate hope of the Endowment Committee. The brochure is self-explanatory in its statement of aims and purposes. It is issued over the name of T. M. Girdler, chairman of the Endowment Committee, and it contains the names not only of the gentlemen who are assisting Mr. Girdler as members of the committee but also of the officers and directors of the Association who will be charged with the administration of the endowment if and when it is successfully established.

It is entirely appropriate that the United States, having many foundations for international peace by various means, have at least one devoted to the exclusive purpose "peace by preparedness." Our present armament experience furnishes ample proof of the continuing need for a strong technical and scientific body pledged to the advancement of armament preparedness for the peace of our country.

A great deal of thought has been given to the work of the committee by its members. Mr. Girdler, the chairman, has been especially active in organizing the committee. The editors of Army Ordnance take this means of extending to him and his associates on the committee not only their thanks for the splendid work done thus far in organizing the group, but also their congratulations on the timeliness of the enterprise and the success which so worthy a project is entitled to receive.

Necrology

COL. JEREMIAH CAMPBELL, charter member of the Army Ordnance Association and formerly a director of the Boston Post, died at his home in Salem, Mass., September 6, 1941. He had retired recently as manager of the Salem Terminal Company and lived at Winter Harbor, Mass.

Colonel Campbell, born in Chelsea, Mass., had lived many years in Salem where he took an active part in civic affairs. He was graduated from the Massachusetts Institute of Technology, served in the Ordnance Department during the World War, and was decorated by the Government of France for meritorious service. A gentleman of charming personality, Colonel Campbell was a loyal and energetic proponent of the Ordnance cause and lost no opportunity to advance both the engineering and military supply problems connected therewith. During all the years since the World War he maintained active contact with the Ordnance Reserve Corps and, at the time of his retirement, was promoted to the grade of colonel.

STEPHEN W. DIMICK, vice-president in charge of the Small-Arms Division of Colt's Patent Fire Arms Manufacturing Company, died suddenly at West Hartford, Conn., August 5, 1941. Mr. Dimick had been a member of the Army Ordnance Association for many years and had taken an active part in upbuilding the organization, particularly in the New England area.

Widely known among sportsmen and handgun shooters in all parts of the country, Mr. Dimick long had been identified with the manufacture of small arms and small-arms ammunition. He was born in Boston and first entered the sporting-goods business there and subsequently became connected with the Winchester Repeating Arms Company. He had been with the Colt Company since 1923 as sales manager. In 1935, he was made a vice-president of the company. During his service with Colt he had charge of western sales and later was brought to the main office and placed in charge of small-arms sales.

COL. EVERETT COLLINS, Ord. Dept., U. S. Army, died suddenly at his home in Columbus, Ohio, July 27, 1941. He was Ordnance officer of the Fifth Corps Area. The following general order, published by Maj. Gen. Clement A. Trott, commanding general of the corps area, describes the life and works of this well-known officer and expresses the sentiment which will be shared by all his friends.

"The death of Col. Everett Collins, Ordnance Department, corps-area Ordnance officer, which occurred at his home on the 27th of July 1941, is announced by the commanding general with deep regret. Colonel Collins was commissioned a second lieutenant of Cavalry, September 9, 1910, shortly after his graduation from Norwich University with a degree of bachelor of science in civil engineering. He was promoted first lieutenant of Cavalry, July 1, 1916, and captain of Cavalry, May 15, 1917. On July 1, 1920, he was promoted major of Cavalry and transferred to the Ordnance Department. He was promoted lieutenant colonel, Ordnance Department, on July 10, 1935, and to colonel on August 15, 1939. He was assigned to duty as Fifth Corps Area Ordnance Officer on August 3, 1938.

"Colonel Collins was a graduate of the Mounted Service School First Year Course in 1915. He served two tours of duty in the Philippine Islands and at various stations on the Mexican Border. He was commanding officer, San Antonio Arsenal from July 1926, to April 1930, and in command of Curtis Bay Ordnance Depot from October 1934, to July 1938. Colonel Collins was at all times found equal to the important and responsible positions in which he was placed during his thirty-one years of active service as a commissioned officer, and his record bears testimony to his high character and fidelity to duty. He displayed at all times the finest soldierly qualifications, loyalty and devotion to his profession which won the commendation of all those with whom he served."

ALVAN T. SIMONDS, president of Simonds Saw and Steel Company, Fitchburg, Mass., widely known in industry, died September 2, 1941, at his home in Boston. Mr. Simonds was assistant chief of the Boston Ordnance District.

Born in Fitchburg, Mr. Simonds was graduated from Harvard in 1899 and studied metallurgy in Sheffield, England. He became president of the company in 1913, later relinquishing this position to his brother, Gifford, and again resumed the post on Gifford's recent death.

Fearless in his espousal of sound economic doctrines, the 109-year-old company of which he was head was referred to by himself as a "paternalistic, autocratic, family affair." At that time, 1938, he was testifying before the Senate Profit-Sharing Committee and said his company would not favor Government supervision of profit-sharing. He said his company had maintained a pension fund for thirty-five years.

Early in 1917, his company offered its services to the Army Ordnance Department. Mr. Simonds became a captain in the Ordnance Reserve and was in charge of the purchase and production of helmets and body armor. Due in large measure to early experiments of the company, more than one million helmets were made of American steel by American manufacturers and were ready for shipment December 1, 1917. As assistant chief of the Boston Ordnance District and a charter member of the Army Ordnance Association, he was held in high esteem by his Ordnance confreres for whom his passing is a real loss.

Ordnance in Review

THE MACHINE GUN—ITS EARLY APPLICATIONS, PART II

LIEUT. COL. CALVIN GODDARD

OF the "mystery piece" mentioned at the close of the preceding installment, we shall have considerably more to say. Meantime, it may not be amiss to revert for a space to certain contemporary machine weapons and to enlarge upon the brief descriptions of these already offered.

The "Coffee Grinder," so-called, was the invention of Wilson Ager (incorrectly spelled "Agar" in Major Fosbery's article—see Part I), an American who, in 1866, took out two British

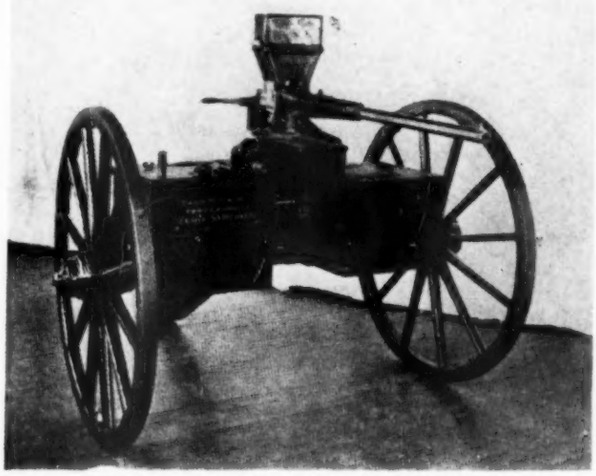

FIG. 3. A CIVIL WAR "COFFEE GRINDER"

patents (Nos. 152 and 1,852) on his piece. Yet a search of U. S. Patent Office records over the years 1856-1870, inclusive, fails to reveal any American ordnance patent issued to one of his name, despite the fact that over this period he was patentee of no less than nine different devices for use in industry—most of these dealing with the cleaning of rice. His weapon embodied at least two characteristics today considered most desirable—a barrel readily dismountable for replacement by a "spare," two or more of which were intended to accompany each gun in the field, plus an attachment for artificially cooling the bore. The latter is outlined in the specifications of the second patent (July 14, 1866) as follows:

"Currents of air are forced by the action of a fan through the barrels of repeating guns to prevent them from heating, and to carry off the smoke and gases, and to clear out the barrels after each discharge. The fan is connected and worked by the action that turns the charge chambers, and is applied to the 'repeating gun' described in the Specification of former Letters Patent dated January 17, 1866, No. 152, which is constructed with an outside casing round the barrel through which as well as through the barrel the blast of air is driven."

The rifled tube with its attached mechanism (Fig. 3—from "Machine Guns," by Hatcher, Wilhelm, and Maloney; Menasha, Wis.: Geo. Banta Co., 1917) mounted by a ball-and-socket joint on a light wheeled carriage of mountain-gun type, was capable of speedy movement in elevation and traverse. Boxes at either end of the axle carried the ammunition supply.

According to Fosbery, the bore diameter was between that of the British Enfield rifle (.577-inch) and the contemporary U. S. Springfield muzzle-loader of the period (.58-inch). The only reference bearing upon the actual employment of this gun in conflict which I have thus far been able to discover is from the same author, who says: "One or more of them were, I believe, used with some show of success during the American (Civil) War for the defense of bridges or narrow passages, and a mantlet carried on the carriage very effectively protected the gun against all small-arm projectiles." His further comments are interesting, as evidence of the fact that the best of critics may err in their prognostications. He says: "This variety of mitrailleur may nevertheless, I think, be fairly considered as disposed of, as not coming up to what is required either in simplicity or power, whilst its supply of ammunition, were there no other reason against it, would obviously be difficult to keep up for any continuous service."

His final observation (difficulty in maintaining ammunition supply) has been the constant wail of the unventuresome since the introduction of gunpowder. Each invention tending to increase the rapidity of fire of small arms has been attended by an outcry to the effect that the problem of ammunition supply would prove insurmountable! Within the memory of some now living, polemics have waxed and waned over this question, as the single-shot breech-loading cartridge weapon supplanted its percussion muzzle-loading predecessor; when the next swing of the pendulum brought in the repeater, and finally, when certain brazen souls made bold to suggest the introduction of a semiautomatic shoulder arm. But in all instances an answer, and a satisfactory one, *has* been found, despite the evil forebodings of the ultra-conservatives.

Fosbery was, of course, correct in his forecast as to the success of the *particular* piece he was describing, but its failure to gain a place in the sun was distinctly *not* due to its two characteristics which he considered most unfavorable; *i.e.*, rapid consumption of ammunition and the discharge of this through a single barrel. True, the original type of ammunition *was* crude, but this drawback was partially corrected by the substitution (*vide infra*) of central-fire metallic cartridges as soon as these had been perfected, and the single barrel, which Fosbery held inadequate in "power" (presumably by comparison with the French and Belgian multibarreled pieces), was destined eventually to supplant all other types.

INDEED, it would appear that Fosbery who, when he wrote his paper in 1869, had made studies of practically all machine guns then existing, was firmly committed to the Montigny (Belgian) system and its French counterpart as developed by Colonel de Reffye and had come to the conclusion that no other types could compare with these. Expressing his mistrust of the ability of a single-barreled weapon to perform satisfactorily, he says: "The only thing forgotten seemed to be that when firing at the rate of 100 discharges per minute, the flame of 7,500 grains of exploded powder and nearly 7 pounds of lead would pass through this single barrel in that time. The effect on trial proved that the barrel grew first red and then nearly white-hot, large drops of fused metal pouring from the muzzle, and the firing had to be discontinued from fear of worse consequences."

At this late day it may be idle to speculate upon the above report, but it seems reasonable to assume, in accordance with practice then prevailing, that the bullets employed were of pure lead—not hardened with any alloy of higher melting point. Further, black-powder fouling was, and remains, a dreadful bugbear—the bore of a weapon, in the absence of suitable and ample lubrication of each bullet fired with this propellant (or the less feasible expedient of a thorough cleaning after every few shots) soon becoming overlaid from end to end with a thick deposit which literally tears off some of the outer layer of each succeeding missile. From which the conclusion would arise that the "drops of fused metal" which the major observed were, in all probability, simply molten lead.

The capped steel cases used in Ager's gun were to all intents

THE TIMETABLE OF ALUMINUM FOR DEFENSE
up to September 10, 1941

1938 Sept. *Munich.*
Oct. *Czechoslovakia invaded.*
Nov. Alcoa inaugurates $26,000,000 expansion program. **1938**
Dec. Alcoa produced 287 million pounds in 1938; had more than a year's supply on hand.

1939 Jan. New extrusion and tube mill begins operation at Lafayette, Ind.
Feb. Start building an excess stock pile of airplane sheet.
Mar. *Bohemia and Moravia occupied.*
Apr. *Albania invaded; Congress authorizes Army to acquire 6,000 planes by July, '41, and Navy 3,000 by '44. Aluminum for all these would take about two months 1941 production.*
Sept. *Poland invaded; U. S. Neutrality proclaimed; limited National emergency proclaimed.*
Alcoa authorizes new metal-producing capacity at Alcoa, Tenn.
Nov. *Finland invaded; Cash-and-carry act signed.*
Alcoa completes $26,000,000 expansion program, begins plans for a larger one.
Dec. *U. S. protests blockade of German exports.*
New metal-producing plant authorized at Vancouver, Wash. **1939**
1939 production 327 million pounds; 215 million on hand.

1940 Jan. *First request for defense appropriation in Budget Message.*
Alcoa announces $30,000,000 more plant expansion.
Mar. Alcoa reduces price of aluminum from 20c to 19c, starts construction of Vancouver, Wash., plant.
Apr. *Denmark and Norway invaded.*
May *Low countries invaded; National Defense Advisory Commission named.*
New metal-producing unit begins operation at Alcoa, Tenn.
June *Dunkerque; France capitulates.*
Additional metal-producing unit authorized at Alcoa, Tenn.
July *Congress lifts previous limits on numbers of planes.*
Aug. *Air offensive against England begins; 50 destroyers exchanged for island air bases.*
Alcoa reduces price of aluminum ingot from 19c to 18c; capacity for making alumina increased.
Sept. *Egypt invaded; Selective Service Bill passed.*
First metal manufactured at Vancouver, Wash., plant and new units for additional capacity authorized. **1940**
Oct. *Rumania invaded.*
Alcoa authorizes another $150,000,000 for expansion.
Nov. *26 bombers on contract turned over to Britain.*
Alcoa reduces ingot price from 18c to 17c; additional capacity authorized at Badin.
Dec. Alcoa 1940 production 413 million pounds; 154 million on hand.

1941 Jan. *OPM established; NDAC says aluminum supply adequate to meet October, 1940, estimates of requirements.*
Alcoa authorizes additional capacity at Alcoa, Tenn.
Feb. *Aluminum put on priorities.*
Mar. *Lend-lease bill signed.*
Alcoa produces 44,000,000 pounds of metal this month.
Apr. *Yugoslavia invaded; U. S. occupies Greenland.*
May 150 million-pound-annual-capacity plant at Vancouver, Wash., completed and operating at capacity. **1941**
June *Crete lost; Russia invaded.*
July *New Government aluminum plants authorized; U. S. occupies Iceland; Japan moves into Indo-China.*
Alcoa produces 53,000,000 pounds this month; Badin unit authorized November, 1940, starts operation.
Aug. *U. S. Government announces Aluminum Company of America will build and operate 3 Government-owned aluminum smelting plants and one for making alumina.*
Alcoa announces ingot price reduction to 15c, effective October 1, 1941.
Alcoa and T. V. A. conclude agreement to unify two great hydro-electric power systems in the Tennessee Valley, which will add at least 200,000,000 pounds to America's annual aluminum producing capacity.
Alcoa produces 54,000,000 pounds of aluminum this month.
Sept. Sites selected for two of the Government-owned aluminum plants and for the alumina plant; railroad, water, and sewage facilities provided; construction contracts being executed.
Alcoa starts construction of 325,000,000 pounds per year additional alumina producing capacity at its own Mobile plant; construction started on additional capacity for 22 million pounds of aluminum fluoride, and 23 million pounds of cryolite annually at East St. Louis; eight new extrusion presses purchased to bring expansion up to 238% of pre-war capacity.
Excess stock pile of aluminum airplane sheet started in February, 1939, being maintained at 5,000,000 pounds.

ALUMINUM COMPANY OF AMERICA

ALCOA ALUMINUM

and purposes everlasting, and, if recovered after being discharged, capable of an indefinite number of reloadings. But this advantage was more than counterbalanced by the fact that, if not immediately salvaged, a matter not simple under field conditions, the supply of these would have been quite difficult to maintain—and the gun was useless without them. Thus it became in a measure less efficient than a piece served simply by loose powder and ball. Further, reloading of the cases must have been time-consuming and must have required for its accomplishment facilities not likely to be available on or near the firing line. And finally, the fact that the bullet had of necessity to pass a gap, no matter how minute, between the front face of its steel container and the proximal end of the barrel (as in a conventional revolver) must have led to unpleasant gas escape and rapid fouling of the mechanism with black-powder residue. This was a defect which even the adoption of an improved metallic cartridge could not correct, and one which, in view of the early perfection of other weapons not so handicapped, was destined to condemn Ager's invention to ultimate failure.

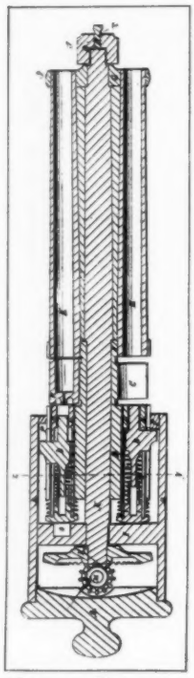

FIG. 4. DIAGRAM OF GATLING MACHINE GUN

It is interesting to observe that Gatling's original gun (Fig. 4: U. S. Patent 36,836, November 4, 1862) employed steel cartridge cases of somewhat similar design and identical function, as evidenced by the following extract from his specifications. (In the first installment of this series there was expressed the erroneous assumption that it functioned with metallic cartridges of the rim-fire type.):

"The hammers . . . are drawn forward against the percussion cap on the nipple of the cartridge chamber (R—Fig. 4) with sufficient force to explode the cap and discharge the cartridge, after which the cartridge holder is carried on around until it drops out of the carrier by its own weight, *when it is ready to be taken up and reloaded*" (Italics ours).

SO it is evident that the first Gatling suffered from some of the same handicaps that beset Ager's earlier pieces and, by the same token, was foredoomed to failure unless these were removed. Both inventors soon became aware of the necessity for improvement, and both undertook to correct the situation, Gatling successfully—Ager not so. For the former, in redesigning his gun for metallic ammunition (of a type basically identical with that now in use), arranged to eliminate the steel casings—and with these, the troublesome gap between chamber and bore—instead, feeding the cartridges *directly* into the breeches of the barrels which constituted his weapon. Ager, however, made the mistake of retaining the special cases, loading these with metallic cartridges in place of the loose powder and ball employed in his earlier practice. He thus failed to solve the problem of ammunition supply, since the individual steel cases remained essential to the operation of his gun, and the bugbear of gas escape between chamber and barrel was still present.

Gatling, who like Ager, had received several patents on industrial machinery prior to turning his attention to ordnance, must have been a man of manifold, and sometimes rudely conflicting, interests. For while he was developing and attempting to interest the Federal Government in his new device, he held at the same time active membership in an organization, then spreading over a number of loyal states, which styled itself the "Order of American Knights" and stood ready to join hands with the Confederacy at the psychological moment.

But such blows as he struck (vicariously) in the conflict were for, rather than against, the Union, since Maj. Gen. "Ben" Butler used some Gatlings during his Virginia campaigns. These were evidently of 1862 pattern, for the improved model (handling metallic cartridges) was not patented until May 9, 1865 (No. 47,631). And although he possessed some twelve of these pieces, the performance of which excited much favorable comment, note has already been made of the fact that he failed to make any reference to them in his extensive autobiography.

A sidelight on contemporary observations concerning this weapon is offered by Professor Shannon where he states (citing Appleton): "The first model of the Galting gun fired 250 to 300 shots a minute. To use it in a battle, according to the report of soldiers, they would 'hitch a horse to the gun, start on a gallop, turn a crank, and the bullets flew almost as thick as hail, mowing down the Rebel lines.' That this description is true in substance is shown by the later performances of the gun. But in spite of its demonstrated effectiveness, the gun created no immediate impression on the Ordnance officers. Yet immediately after the close of the war, the Gatling gun, in an improved form (evidently the 1865 model), was adopted by the United States for the Army."

Although the observation just quoted may be true in substance, it is obviously erroneous in detail. For the spectacle of a soldier flattened out on the trail of an artillery carriage mounting one of Gatling's pieces, hanging on for dear life with one hand and cranking the weapon (if he could) with the other, muzzles oscillating between ground and sky as the wheels bounced over inequalities in the terrain, is scarcely compatible with the delivery of a hail of bullets "mowing down the Rebel lines." And since the Gatling, like other self-respecting weapons, will not shoot around corners, it would have been necessary to maneuver the gun, trail-foremost, to within easy rifle shot of the enemy, then to do an about-face and commence firing as the terrified beast hitched to it dashed madly to the rear—during all of which, the Confederates doubtless stood quietly at attention, waiting to be "mowed"...!

SINCE the above lines were written, I have had the extreme good fortune to receive from Lester L. Swift, of Cleveland Heights, Ohio, citation of an instance of the employment of the Gatling by General Butler in Virginia. This he was kind enough to copy for me from the unpublished "Personal Recollections" of Capt. Gustavus S. Dana, Signal Corps (Regular Army), attached to the staff of Maj. Gen. Quincy A. Gillmore, commanding the X Army Corps, Army of the James. From the context, Mr. Swift concludes that the happening described below took place between May 12 and 20, 1864. Dana says:

"The entrenchments we had erected were from the Appomattox to the James across the neck of land at its narrowest part west of Bermuda Hundred, and the position was described by General Grant as being 'corked up in a bottle.' Beauregard had entrenched across the front of us and our salients were at one point only thirty yards apart. My signal party were stationed at these batteries to direct each others' fire and to communicate with the Navy and our various headquarters. Nearly every day there would be a fierce attack from one side or the other, sometimes the Rebels getting over our works and sometimes we over theirs. I saw General Butler testing the Gatling gun, which was a new thing then, upon some unarmed and unsuspecting Rebels who were strolling up and down the top of their earthworks talking to our men in the rifle pits during one of those mutually agreed upon armistices the enlisted men used to have. It brought on quite an artillery duel. . . ." *(To be continued.)*

EDITOR'S NOTE.—Upon completion of this series of articles on machine guns, they will be reprinted in brochure form and copies will be available for ARMY ORDNANCE readers without charge.

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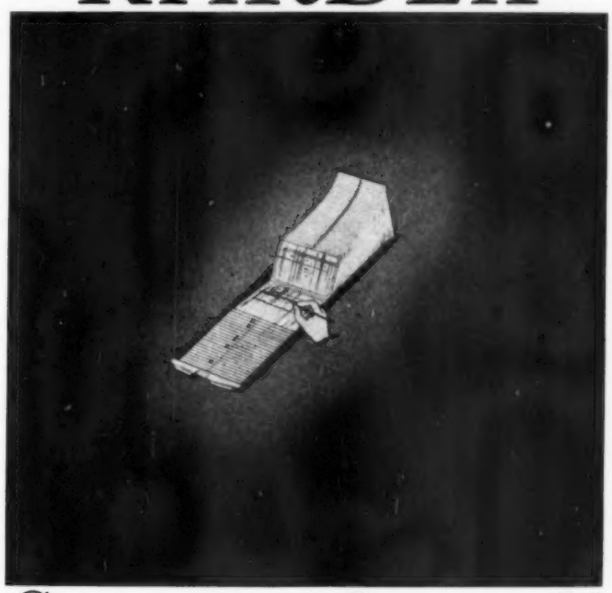

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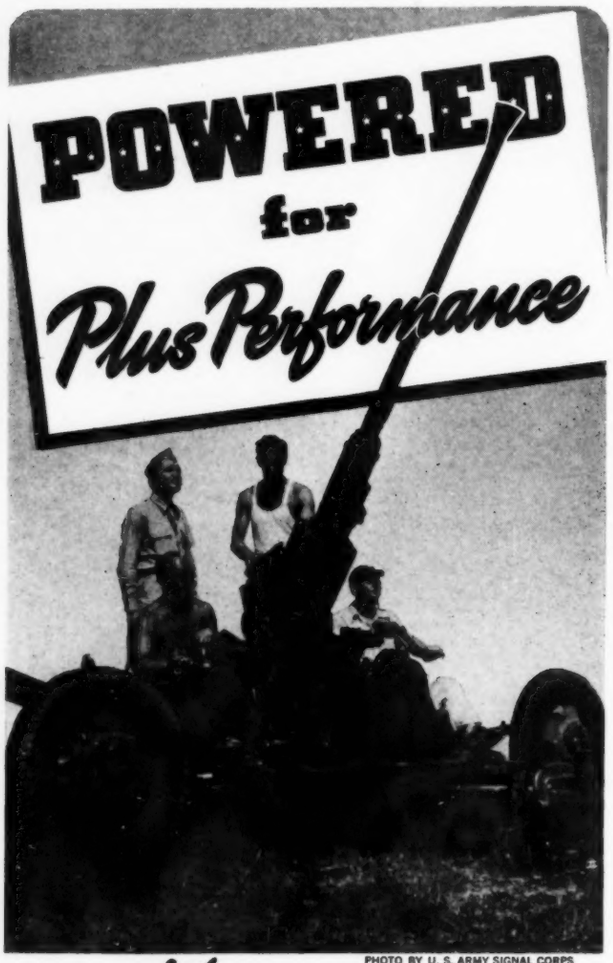

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Ordnance Personnel

New Age Standards

NEW age standards for commissioned officers have been fixed by the War Department in a policy that is intended as an important step toward the vitalization of the field forces by insuring that all officers serving with troop units are within the ages which permit the efficient continuous performance of field duty under the arduous conditions of modern field service.

The policy affects, with certain exceptions, all officers serving with troop units in the three components of the Army—the Regular Army, the National Guard, and the Officers' Reserve Corps. Overage officers now serving with troop units will be transferred to administrative or staff duty away from troop units and replaced by younger officers. Those overage officers of the Reserve components for whom appropriate positions elsewhere are not available will be relieved from active duty after they have completed twelve months' training. Under certain conditions, overage Reserve and National Guard officers may be relieved from active duty before they have finished twelve months' training if they so desire.

The new age standards apply to officers of the grades ranging from second lieutenant to major general (division commander). Army-corps commanders, who are major generals, and army commanders, who are lieutenant generals, are not affected. The age-in-grade limitations for service with troop units are as follows: Major generals (division commanders), 62; brigadier generals, 60; colonels, 55; lieutenant colonels, 52; majors, 47; captains, 42; 1st lieutenants, 35; 2nd lieutenants, 30.

Because of the need for the maximum number of Air Corps officers and the fact that there is a heavy demand for nonflying officers for service with the air forces, units and installations of the Air Force are not classed as troop units under the age-in-grade policy, and the age limitations will not, for the present, apply to officers serving with the Air Force.

Reinstatement of Reserve Commissions

A CHANGE in policy affecting the reinstatement of former Reserve officers to conform to the age standards of Selective Service has been made by the War Department. Under the new ruling, former Reserve officers between the ages of 21 and 28 may be reappointed in the lowest grade of their former branches, provided that: (1) their original appointment as a Reserve officer was made subsequent to 1933; (2) they were in an eligible status at the time their Reserve appointment was terminated; (3) their appointments were not terminated for misconduct or similar cause; (4) they pass a final-type physical examination; (5) they have the approval of the corps-area or department commander or chief of arm or service concerned; (6) they attain a certificate of capacity.

Applicants, in the event they are reappointed, will be ordered to extended active duty for at least a year whenever their services are required. However, no individual will be appointed until after he has obtained a certificate of capacity. Previously, former Reserve officers could be reappointed up to 36 years of age.

Units of National Guard to be Returned to State Control

INSTRUCTIONS issued by the National Guard Bureau provide for the administration of the National Guard in the home states in connection with the progressive release of individuals from active service and their return to state control. Enlisted

men being returned to state control are to be carried on the rosters of state detachments and accounted for until the expiration of their enlistment periods as extended by the President's Executive Order of August 21, 1941.

The purpose of these orders, the instructions say, is twofold: First, "to protect the interests of National Guard personnel by continuing their service under state control in order to permit their records to show the number of years in Federal service and state service necessary to meet the requirements of the Selective Training and Service Act." If this action had not been taken, those men would have become subject to the draft. Secondly, the purpose is "to furnish the states a means of maintaining a trained and classified nucleus from which the National Guard may be rebuilt."

Since practically all National Guardsmen who are relieved will have completed a year of active-duty training, no provision is to be made now for army drill or field training for this class of personnel.

The instructions specifically state, however, that the returned personnel may be permitted to affiliate themselves with local State Guard units without prejudice to their National Guard status.

POLITICAL ACTIVITIES

THE War Department has cleared the way for soldiers of Reserve and National Guard components of the Army desiring election or reëlection to public office to campaign and hold office if their political activities do not interfere with military duties. Each request to engage in political activity while serving in the Army of the United States will be considered individually when circumstances justify such action. Army Regulations normally prohibit soldiers on active duty from taking "active part in political management or in political campaigns."

REAPPOINTMENTS IN OFFICERS' RESERVE CORPS

NO officer of the Officers' Reserve Corps will be reappointed at the end of the 5-year term of appointment if he is not available for extended active duty at the end of the term of appointment. When the 5-year period in any section or grade expires, commissions in the Active Reserve Corps will be terminated if the officer has failed to establish his eligibility for promotion, assignment, and active duty in peace time. If such an officer had less than one year to serve on August 1, 1941, he may be reappointed in an ineligible status, in which case eligibility must be attained within one year after reappointment or his commission in the Active Reserve will be terminated.

TEMPORARY PROMOTIONS

APPROXIMATELY 3,700 officers of the Regular Army and the Officers' Reserve Corps will get temporary promotions under a policy recently made effective. The temporary promotions for Reserve officers will be principally to the rank of 1st lieutenant and captain while the Regular Army promotions will include higher grades. Advancement for Regular Army and Reserve officers in the lower grades has been made possible by a reduction in the number of years of service required for permanent promotion.

The following Regular Army officers will be eligible for selection for promotion to temporary grades in the order in which their names appear on the promotion list: Majors with from twenty-two to twenty-three years' service in the Regular Army; captains with twelve years' service; 1st lieutenants with three years' service; 2nd lieutenants with one year's service. Captains of the Medical Department and Chaplain Corps with nine years' service will be promoted according to relative rank.

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Professional Digest

The following items of current information and opinion aim to present a wide range of facts and discussion relating to recent developments of professional military interest. Quotation marks are frequently omitted but sources are indicated.

THE 5TH ARMORED DIVISION OF THE ARMY'S ARmored Force was created October 1st at Fort Knox, Ky. In the organization of the new unit, cadres from existing divisions will be augmented by trainees from the Armored Force Replacement Training Center at Fort Knox.

The 1st and 2nd Armored Divisions of the Armored Force were activated on July 10, 1940, and the 3rd and 4th Armored Divisions on April 15, 1941, under the command of the late Maj. Gen. Adna Chaffee. The 5th Armored Division is the first to be activated under the direction of Maj. Gen. Jacob L. Devers, who replaced General Chaffee when the latter retired because of ill health. In make-up, the 5th Division will be similar to the other four, each of which has five echelons which include: (1) A command echelon, comprising the division headquarters and a signal company; (2) A reconnaissance echelon, comprising a strongly armed reconnaissance battalion, with fast scout cars, a light tank company, and motorcycles; (3) A striking echelon, comprising an armored brigade of two light- and one medium-tank regiments and an artillery regiment; (4) A support echelon, comprising an infantry regiment, an engineer battalion, and a field artillery battalion that includes an antitank section; (5) A service echelon, comprising an ordnance battalion, quartermaster battalion, medical battalion and (in march and combat) the field trains of the other echelons.

The authorized strength of an Armored Division is approximately 12,000 men. The 5th Armored Division initially is being activated at reduced strength.

LESSONS LEARNED FROM THE EUROPEAN WAR are being put into practical use by the U. S. Army as soon as possible. One of the most interesting lessons—and one which will save the lives of many American soldiers—is that of redesigning the rivets in tanks and the casting of the armor of tanks in as few pieces as possible. At the outbreak of the European war, virtually all countries riveted armor on tanks. After a few battle engagements, particularly in France, it was found that when tanks were struck by shells the force of the shell sheared off the rivet heads on the outside of the tanks. The driving force of the explosive then forced these cut rivets through their holes with such force as to spray the inside of the tank with broken rivets, and a high number of casualties resulted.

In an effort to reduce such casualties, Army Ordnance experts began redesigning the rivets placed in American tanks. Redesigning, it was found, reduced the possibility of the broken rivets spraying the inside of the tank. Ordnance experts then found that the armor could be fitted on with little or no reduction in strength by a new welding process. This process has met with greater success than the redesigned rivets. The armor is cast with beveled edges and when welded together produces a smooth exterior so that bursting shells—although they might weaken the welds to some degree—cannot drive metal inside the tanks.

FIFTY-FOUR HIGH-SPEED, SELF-PROPELLED GUN mounts for the Army's new provisional Tank Destroyer Battalion were delivered by the Ordnance Department in less than sixty days after the equipment was ordered. Design and development were conducted at Aberdeen Proving Ground, Md., after the order was placed June 27, 1941. Commercial concerns built

the gun-carrying vehicles; the guns were mounted and deliveries were completed during the week of August 17th. On August 27th, the Tank Destroyer Battalion made its first demonstration as a unit at Fort Meade, Md. As currently constituted, the battalion consists of 36 armored half-track cars mounting 75-mm. guns, 18 "jeeps" and "swamp buggies" mounting 37-mm. guns, and 10 light tanks.

The half-track cars, mounting 75-mm. guns, carry a crew of 4 men, a 2-way radio, have a gross weight of 17,500 pounds, including the crew, are capable of 50 miles an hour, and possess a high degree of cross-country mobility. The 75-mm. gun is so mounted that the driver of the self-propelled gun mount can remain in his place when the gun is fired. Position of the gun enables the half-track car to be hidden behind a rise of ground, with only the gun itself exposed to view. The gun crew is protected by an armor-plate shield. The gun's elevation and traverse correspond to those of the standard mount. The pilot model of the half-track car with 75-mm. gun was constructed at Aberdeen Proving Ground.

The "jeeps" mount 37-mm. guns, some with the gun facing forward and others with the gun facing to the rear. The "super-jeep," or "swamp buggy," constructed at Aberdeen Proving Ground, is a 4-wheel-drive, underslung vehicle with an unusually low silhouette. Its 37-mm. gun points forward, its engine is in the rear, and its crew includes a driver, gunner, and loader.

AN ORDNANCE MAINTENANCE BATTALION CARries complete tools and replacement equipment for ninety to ninety-five per cent of the shop-maintenance work for an armored division's weapons and mechanized equipment. Official records show that in the recent Second Army maneuvers in Tennessee no mechanical equipment or vehicles were out of operation for want of repairs or spare parts. This achievement is credited to the Ordnance maintenance battalions whose truck shops worked throughout the nights on disabled vehicles, restoring each to operation by morning. In addition to its maintenance vehicles for protection in the field, each Ordnance maintenance battalion has six scout cars with armament, including light and heavy machine guns, submachine guns and automatic pistols. It includes 3 artillery-repair trucks, 3 automotive-repair trucks, 32 emergency-repair trucks, 2 instrument-repair trucks, 3 major shop trucks, 5 small-arms repair trucks, 20 small-parts trucks, 3 tank-maintenance trucks, 3 tool-and-bench trucks, 5 welding trucks, nine 10-ton heavy wrecking trucks, 2 sedans, 12 solo motorcycles, one 250-gallon water trailer, 6 motor tricycles, 4 ½-ton command trucks, one 1½-ton cargo truck, forty-nine 2½-ton cargo trucks, and three 600-gallon gas-and-oil trucks.

AN INFANTRY AIR-BORNE BATTALION, EQUIPPED with "jeep" reconnaissance cars, motorcycles, and folding bicycles to be used with parachute troops, is in the process of formation at Fort Benning, Ga. Designated the 88th Infantry Air-borne Battalion, its initial strength will be 500 men. The unit will be trained in air-landing operations during which extensive tests of equipment will be made. Men for the new unit will be selected from volunteers. Qualifications, generally, are the same as for parachute troops. The battalion will include two rifle companies, one heavy-weapons company, and a headquarters company. One of the rifle companies will be equipped with motorcycles and a number of "jeep" ¼-ton reconnaissance trucks.

THE THREATENED SHORTAGE OF SILK WILL not affect too seriously the supply of cartridge cloth used by the artillery of the United States Army because the Ordnance Department has developed satisfactory cotton loading bags for most purposes. Experiments with cotton cartridge cloth began seven years ago, and the Ordnance Department is prepared to procure an ample supply of cotton bags that may be used for most artillery purposes. Silk is required for various twines and tapes. Silk tie straps still will be used for the heavier charges and silk

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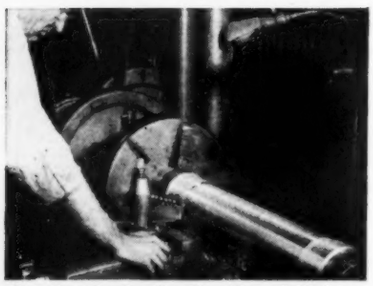

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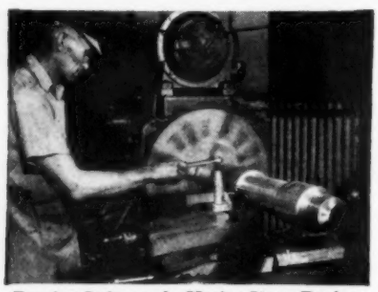

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powder bags for the very heavy caliber guns, but further experiments are being conducted with a substitute material to be used in loads for guns of the higher calibers.

THE ARMY IS PACING THE CURRENT RAPID EXpansion of the commercial plastics industry in adapting plastics to national defense. Chief interest of the Ordnance Department in plastics is for use as components of shells and bombs. Extensive experiments have been or are being conducted with plastic false windshields for 37-mm. armor-piercing shells, bodies of bomb fuzes and fins for mortar shells. Rigid specifications necessarily have been imposed due to the exacting performances demanded of today's high-speed warfare. For example, plastic caps on certain armor-piercing shells must be accelerated, in their short 4-foot trip through a gun barrel, to a velocity of 2,800 feet a second, and must at the same time acquire a spin of more than 10,000 revolutions a minute.

THE ARMY HAS STARTED A REORGANIZATION of the headquarters and service troop and the special-weapons troop of horse cavalry regiments to provide greater antitank protection. Basically, the plan requires the replacement of cal. .50 antitank machine guns with 37-mm. antitank guns; pack animals will yield to motorized weapons carriers until a suitable antitank gun that can be packed on animals is developed. The plan ultimately will affect the composition of the headquarters and service troop and the special-weapons troop in the 10 regiments of horse cavalry in the 1st and 2nd Cavalry Divisions and the 56th Cavalry Brigade; and in the 3rd and 11th Cavalry Regiments, which are separate units.

Under the provisional plan, the special-weapons troop, now part horse and part motor, will be completely motorized. In place of its eight cal. .50 machine guns it will receive six 37-mm. antitank guns. Its four 81-mm. mortars will be retained. Its 143 riding horses and 40 pack horses will be replaced entirely by motor vehicles.

The scout-car platoon and the motorcycle platoon will be eliminated from the headquarters and service troop and will be transferred to the special-weapons troop, where they will be combined into a single large reconnaissance platoon. The removal of these two platoons is the only change that will occur in the headquarters and service troop.

THE WAR DEPARTMENT IS CONSERVING VITAL materials such as aluminum, rubber, silk, zinc, copper and nickel used in defense production by substituting more readily available materials in hundreds of articles of equipment purchased for the Army. Quantities of critical defense materials have been eliminated or reduced in specifications for approximately 300 different pieces of equipment purchased by the Quartermaster Corps. New specifications already have been made for nearly as many more items, to take effect when manufacturing begins to replace supplies now on hand.

Brass and bronze have been eliminated from belt buckles, rifle scabbard snaps, nuts, bolts, and electric fixtures. Malleable iron and steel have been substituted in ninety-six items of equipment manufactured by the thousands for the Army. In the search for a nickel substitute, the Army has turned to wood, vitrified clay, cast iron, galvanized iron, steel, and glass. The substitute materials receive a special finish to make them suitable for use in all sorts of table tops used in Army kitchens and hospital laboratories, electric fixtures, steam kettles and half a hundred other items. Zinc has been saved in more than fifty different pieces of equipment by substituting methods of galvanizing and finishing on such things as galvanized piping, electric tubing, fences, armored cables and steel flagpoles. Elimination of zinc in brass and bronze also has saved quantities of this element for more important uses. Fiber glass and "rock cork" have been substituted for cork. Wood and concrete have replaced steel wherever possible in Army construction specifications.

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Bullet resistance of age-hardened aluminum wrought alloys

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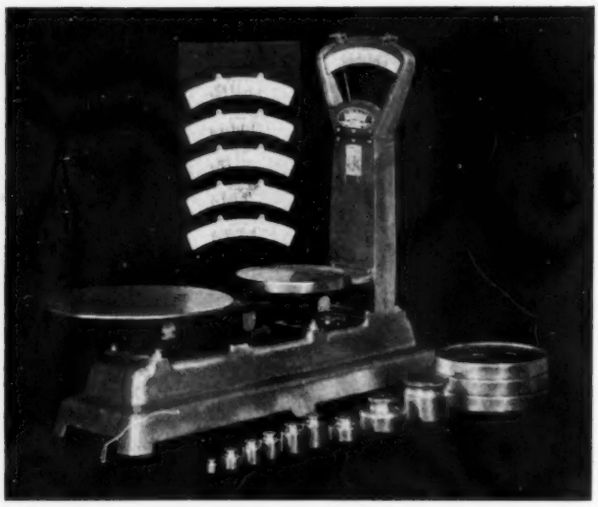

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Book Reviews

ORDNANCE SAFETY MANUAL. Compiled in the Office of the Chief of Ordnance. Washington, D. C.: U. S. Government Printing Office. 25¢. (Order from Superintendent of Public Documents.)

THE release by the Ordnance Department of a new safety manual is both timely and significant. Many of the plants which form the vast network for the production of explosives and ammunition have been built—their construction following the principles of "built-in" safety embodied in the new manual. The flow of material from these, and from existing installations, has reached the stage where definitions of policy and procedures are most valuable when reduced to book form for ready reference by those who must produce, store, handle, and transport immense quantities of munitions.

Ordnance Department safety principles were first reduced to book form in 1923. Since then, the manual has been revised twice. The current revision amounts to a rewrite, incorporating material and experience developed since the previous revision in 1931.

The manual is confined in scope entirely to explosives and ammunition, and although the requirements apply only to Ordnance establishments—arsenals and depots under the control of the Chief of Ordnance—the principles and procedures laid down are applicable anywhere to the processing of explosives and ammunition.

The manual is divided into four parts. Part I comprises general regulations applicable to any type of plant or depot and to all classes of military explosives and ammunition. Specific regulations and descriptions of military explosives and ammunition are covered in Part II. Special regulations for manufacturing and loading establishments are given in Part III, and special safety regulations for the storage and handling of chemical ammunition are covered in Part IV.

Section 1 has been entitled the "Introduction" and comprises statements of the purpose and scope of the manual together with general definitions and a bibliography. The mandatory requirements of the manual must be complied with except when specific exemptions are authorized by the Chief of Ordnance. An important change has been made regarding compliance with advisory provisions. These must now be complied with generally and may be set aside only when authorized by the commanding officer of an establishment.

SECTION 2 comprises general safety regulations. Responsibility for safety is specified as it applies to the Chief of Ordnance, commanding officers, safety officers, fire marshals, and trained employees. A new duty not before specifically stated is now required of commanding officers. This concerns storage and requires that a report be made to the Chief of Ordnance in any case where conditions become such that an explosion or fire may propagate throughout an establishment. The conditions which might cause such a disaster are defined in sections 4 and 5.

New material has been added with regard to industrial health hazards and the disposal of industrial wastes. Manufacturing establishments are required to provide waste disposal which will not contaminate surface water. Attention is directed to the health hazards of toxic materials, and advice regarding the control of health hazards is offered. In this regard, it is of interest that surveys of all Ordnance establishments recently have been made by the United States Public Health Service for the evaluation of such hazards, and appropriate programs are now being devised for the various arsenals based upon the results of these surveys.

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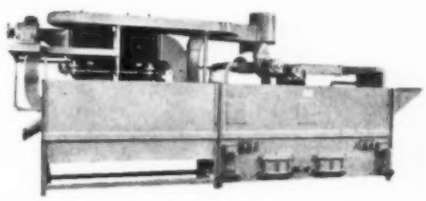

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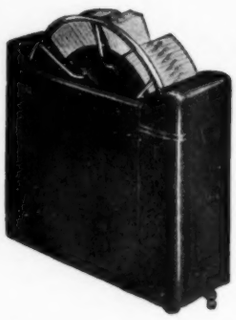

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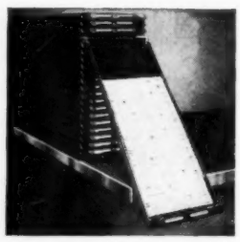

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Section 3, which deals with fire protection, remains essentially unchanged except for the addition of several new topics. The practice of humidification as a means of insuring against the building-up of charges of static electricity also is treated. It is pointed out that this practice, which is relatively new and has not been fully explored, should not be accepted as a complete answer to the problem. Two new paragraphs have been added on the subjects of water mains and fire hydrants in explosives areas.

SECTION 4 is one of the most significant chapters in the manual. It deals with the storage of explosives and ammunition and is specifically designed to apply to storage depots rather than to manufacturing arsenals. In fact, the provision is made at the beginning of the chapter that arsenals or depots which have the older types of magazines or which store only limited quantities of explosives or ammunition must comply with the spirit of the regulations in endeavoring to obtain maximum protection rather than be bound by them in such a manner as to make these establishments inoperable.

In former years it was the practice to store explosives and ammunition in magazines designed and constructed to accommodate specific materials. These magazines were designated explosives magazines, smokeless-powder magazines, ammunition magazines, and primer and fuze magazines. In recent years the Ordnance Department standardized on arch-type reënforced-concrete magazines (universally dubbed "igloo" magazines). These magazines are composed of a reënforced-concrete arch approximately 29 feet wide at the base over a concrete floor and are covered with earth, which is usually sodded or seeded to encourage the growth of grass, thereby giving some camouflage to the area from the air. At the rear of the magazines the earth is gradually sloped off, but at the front the magazine terminates in a perpendicular concrete wing wall and a steel door. Magazines are constructed in three lengths—approximately 42 feet, 62 feet, and 82 feet.

All explosives and ammunition, except small-arms ammunition, preferably should be stored in these magazines. The older types of magazines may now be used for the storage of any material for which they are suitable. One caution should be observed here: Concrete igloo magazines constructed in accordance with standard drawings are considered barricaded *per se,* but no other types of magazines are so considered unless separate barricades are provided.

In the construction of new magazine areas, igloo magazines are separated by 400-foot intervals, and, if they are unbarricaded at the door ends, rows must be staggered to provide a safety distance of 800 feet from front to back of alternate magazines. In this arrangement, magazines are so located that the front of any one magazine faces the rear of the one ahead of it. The rear ends of these magazines are protected by a considerable mound of earth which acts as a barricade.

A VERY interesting and important principle regarding the laying out of explosives areas and magazine areas in particular, has been introduced in this section. The principle is presented in the form of advisory requirements which provide for the segregation of ammunition and explosives within magazine areas but applies only to the older, above-ground-type magazines. Such magazine areas should be segregated into groups of magazines, the distances between groups being such that a fire or explosion in one group will not propagate to adjacent groups. The principles are advisory, but it is pointed out that the probability that one explosion would result in progressive damage increases in proportion to the extent to which these principles are relaxed. Actually, these principles affect only a few depots because they apply only to the older-type above-ground magazines. Areas of igloo magazines are totally exempt from these requirements. Due to their construction, it is logical and within requirements that any type of explosives may be stored adjacent to any other type provided the magazine is a concrete igloo.

In the old manual, no provision was made for shipping and receiving buildings and platforms. Several paragraphs have been introduced into the revised manual prescribing explosives limits, defining their location and the operations which may be performed at such structures. The main point made in these paragraphs revolves around the contingency that a depot often receives railway cars in which ammunition and explosives have been stowed together in accordance with I.C.C. regulations which are more liberal than Ordnance regulations. To allow such a car to enter an Ordnance establishment would be a violation of principles unless some special provision was made for receiving them. These new requirements permit such shipments to be brought into a depot but define rigidly the conditions under which this may be done.

PERHAPS the most important single part of the safety manual is embodied in section 5. It deals with quantity-distance requirements. This section has been entirely rewritten and embodies an exhaustive treatment of the highly important subject of the relationship between quantities of explosives or ammunition and the distances at which they must be stored from adjacent structures to prevent large-scale damage in the event of an explosion. It also treats of the distances at which they must be separated from each other to prevent a single exploding magazine from propagating throughout an entire area and causing a major disaster. Numerous other features incident to minimizing the losses and damage which may result from single explosions are involved in the subject of quantity-distance.

The terms used in this chapter are defined at the beginning, followed by an excellent discussion of the significance of the quantity-distance relationship to hazards. This discussion is presented in one paragraph entitled "Explosives Hazards and Quantity-Distance Requirements." This paragraph, comprising a number of different subheadings, is perhaps the most comprehensive and concise presentation of this subject that has yet been published. Following this discussion are presented the twelve classes of military explosives and ammunition with their accompanying tables and the notations of the special regulations which apply to each class.

PART II comprises the special regulations for specific ammunition and explosives along with a large amount of descriptive matter. Ammonium nitrate is discussed in the section on high explosives, although it is pointed out that this material is explosive only under the influence of a sufficiently heavy initiation.

Safety provisions regarding the storage of bombs now classify fragmentation bombs packed in metal crates in the same category with demolition bombs. Fragmentation bombs packed in this manner are susceptible to mass detonation. Bombs must never be stored fuzed, but in the case of metal-crated 100-pound bombs, provision is made for the storage of fuzes and primer detonators in the same magazine but not assembled to the bomb.

Part III comprises regulations applicable to manufacturing establishments. This chapter comprises three sections, the first of which is devoted to operating regulations, the second to safety standards, and the third to a description, along with the safety precautions, for a large number of hazardous materials, inflammables, and explosives not covered in other parts of the manual. Chemical ammunition, which may be stored by the Ordnance Department, is discussed in Part IV.

The new Ordnance safety manual reflects a large amount of study and careful analysis. Adherence to its principles should result not only in increased safety among the personnel who manufacture, handle, and store ammunition and explosives, but also should reduce to a minimum the probabilities that facilities for producing and storing large quantities of ammunition will be lost or damaged in the future.

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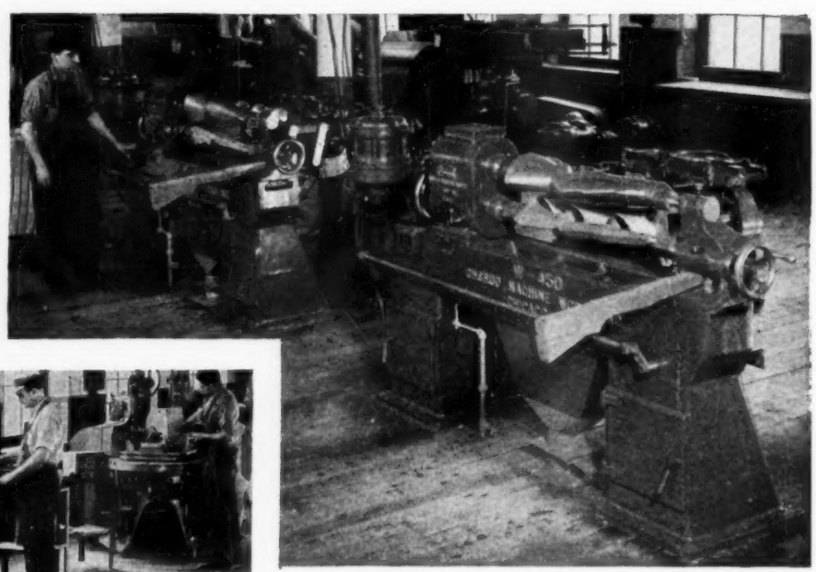

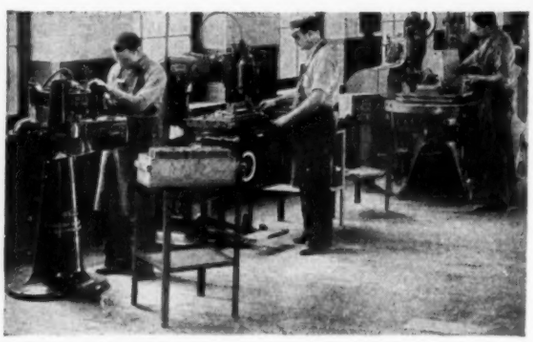

These pictures show a few of the Onsrud Machines at Springfield Armory (48 in all). Photos courtesy U. S. Army.

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